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GEOLOGICAL SURVEY
OF
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907 Walnut St., Phil'd'a.

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I.

PHOTOGRAPHIC MAP REDUCTION.

By O. B. HARDEN, Active Member of the Club.

Read October 2d, 1886.

THE reduction of maps and plans, forming as it has a large part of the work of the drawing office of the Geological Survey, has led to the constant use of the Camera in reducing and duplicating the maps which have been placed at its disposal, and believing that its general use would be to the interest of engineers, I desire to call the attention of the Club to this method of reduction.

The first use of the Camera by the Survey for this purpose was in 1883, when it was desired to have a quicker and cheaper method of reducing the large mine maps of the coal operating companies to the working scale of the Survey, a reduction of from 100 feet to 600 feet to one inch. It was found to be so large a saving of time and labor (having up to this time used the Pantagraph), that all the maps since that time of any magnitude have been so reduced.

Having to make use of the existing information in the special areas in which work has been prosecuted, it has been frequently necessary to have maps reduced and duplicated in the shortest possible time, in order that the original maps might not be long

away from the offices in which they were frequently used. This is especially true of railroad maps. The time necessary to do this became a matter of importance, and as the most accurate, quickest and cheapest means of reduction, they have been reduced by the Camera.

The maps have been of a variety of scales, from 100 feet to 1 inch, to 6 miles to 1 inch, and have been reduced as small as 10 miles to 1 inch. It has not been found that the size of the reductions affected in any way their accuracy. It may be remarked that however small, there is that fidelity in detail that is only equalled by the photographic lens. To those who are accustomed only to the more common methods of reduction and the fallibility of the ordinary draughtsman, this fidelity to detail is gratifying. Even by the use of the Pantagraph and rectilinear lines, the reduction may be accurate in length and breadth and yet be perceptibly wrong within a square, dependent upon the care of the draughtsman.

In many cases the mine maps reduced, being in the conventional color of the bed, have not photographed well, especially so in the case of ultramarine and purple shades, which have to be strengthened on the print in order to be observed through the tracing cloth. This is so with the specimen prints of the workings of the Pennsylvania Coal Company.

The beautiful regularity of the mine workings shown in these reductions is a marked feature.

The originals of the alignment of the Pottsville and Mahanoy Railroad were drawn in colors, black, chrome-orange, purple, red and green, and as shown on the prints it has been necessary in the case of the red and purple lines to strengthen them. I desire to call special attention to these prints as being typical of the work of Messrs. Julius Bien & Co., of New York, who do this work for the Survey. The green color having been made up of yellow and blue, the yellow on the original has separated and produced a heavy blurred line. The contour lines are drawn in chrome-orange. The lines drawn in black appear the most distinct, hence it is preferable that maps should be in black to photograph well.

The scale of these prints is 1 mile to 1 inch, reduced from

1,000 feet to 1 inch. It is necessary in joining them together that it be quickly done and as little paste used as possible, as the paper is very sensitive. It is more expeditiously done by overlapping the prints and pricking holes through two common points on each, mark out and cut off the one print to overlap the other half an inch, paste the lower print and stick the pins back into the same holes; the two prints are then co-incident.

There is practically no limit to the size of map which may be photographed, as it is only exposed to the Camera in sections of about five feet square, when the negative required be as large as 21x25 inches, this being the largest size taken by Bien & Co.

The maps are reduced to their proper size by the operator tacking a strip of paper with the original scale upon it, above the section of map to be reduced, another strip being cut the reduced size and held up to the ground-glass of the Camera until it is so focused as to be the required scale.

The only element of error entering into the reduction of maps by the Camera, aside from the care and skill of the operator, is the expansion and contraction of the sensitive paper. It should, however, come back to its original size after immersion; if it is found not to do so, an allowance is made by making the scale larger or smaller as the case may require. The accuracy of the reduction depends as much upon the perfect adjustment of the map at right-angles to the line of sight as to the scaling by the operator.

It is unnecessary more than to mention that there is no error due to distortion, this being compensated for by the combined lenses used for such work.

The largest maps reduced for the Survey are the splendid topographical maps of the Philadelphia Water Department, being the results of its Surveys for a future water supply for Philadelphia.

These maps cover an area of 446 square miles in Montgomery and Bucks Counties, and have been reduced from 400 feet to one inch, to 1,600 feet to 1 inch. The area of original map-surface is about 773 square feet. The area of map-surface of the prints when put together is about 193 square feet. The reduc-

tion of this immense surface has been made in 30 negatives. The maps are made in colors, the roads yellow, the timbered areas green, the buildings in red and the streams in blue.

In order to prevent any error resulting from the shrinkage or imperfect joinage of the prints, a templet will be constructed for the final map, with the lines of latitude and longitude on a polyconic projection drawn upon them, these lines being on the original map.

A comparison of cost shows that there is a saving of about 40 per cent. over the other methods of reduction. This is where a reduction alone is required and where the map will answer its purpose upon the sensitive paper; where, however, the map is required upon tracing cloth, or where it has to be transferred to a more substantial paper, the saving is about 30 per cent.

II.

REVIEW OF THE FREIGHT BRAKE TRIALS.

By W. E. Hall, Active Member of the Club.

Read October 2d, 1886.

The question of an efficient freight car-brake and coupler is assuming more importance to railroad companies every day, on account of the demands for high speed and the constantly increasing tonnage, which it is desired the transportation department should handle with as little increase of expenditure for equipment and way as possible. The question of the interchange of cars is receiving stronger recognition as its importance grows and the desirability—in fact, necessity—of uniformity in the parts of cars which plays so much importance in their transfer, must be accepted as a point which will materially affect the cost of the transportation of freight.

A review of the results forming the first part of the programme of the tests made by the Master Car Builders' Committee at Burlington, Iowa, during July and August, 1886, have placed the several competitive brakes in the market on their respective

merits, and further show what the railroad companies may expect, and how near any or all of these systems meet the requirements, from the use of any of the mechanical braking appliances there tried.

The trial is to consist of three parts:—the first, the efficiency as regards lengths of stops and general action of the brakes; the second, the endurance or service test when a careful record of the cost of repairs to the several brakes, while in actual service, is to be kept; the third, a repetition of the first after one year of wear and tear, the cars not to be prepared for trial, but to be taken directly from service to Burlington.

The results obtained from the first part of the trial have thrown considerable light upon the question of freight-brakes, and have furnished sufficient information to enable definite conclusions to be drawn as to what may be expected from the several types now, or were previous to this trial, in active competition with one another. They have also shown as to what extent the best braking systems meet the requirements of American railroad practice.

What were known as the general tests were such as could be entered by any of the brake companies represented at the trials. They were simply direct stops at the several speeds with different make up of trains, which included only the one important function of distance run in making stops, but note was made of whatever difficulty or damage might result as well as the general action of the brake.

The efficiencies as shown by these results will first be considered.

With all trains two (2) stops were made on a level, or approximately such, and two (2) on a grade of fifty-four (54) to fifty-six (56) feet per mile, the stops with fifty (50) car loaded trains from speeds of twenty (20) and thirty (30) miles per hour, and all others from twenty (20) and forty (40) miles per hour. The best stop, distance in connection with speed, is given in all cases:—

50 Car Loaded Train.—Brakes on all Cars.

Name of Brake.	Stop 1.		Stop 2.		Stop 3.		Stop 4.	
	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.
American. . . .								
Eames.	728	19½	1423	30½	1036	22½	2787	34½
Rote.								
Westinghouse. .	709	22½	1396	36½	834	23½	1959	39½
Widdifield and Button. . . .								

50 Car Mixed Train.—Brakes on all Cars.

Name of Brake.	Stop 1.		Stop 2.		Stop 3.		Stop 4.	
	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.
American. . . .								
Eames.	710	20	1610	36	976	22½	2505	41
Rote.								
Westinghouse. .	608	20½	1329	39	655	22	1811	43
Widdifield and Button. . . .								

50 Car Empty Train.—Brakes on all Cars.

Name of Brake.	Stop 1.		Stop 2.		Stop 3.		Stop 4.	
	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.
American. . . .	424	21	1518	35	445	20½	1901	34½
Eames.	437	22	1016	38	448	22	1399	40
Rote.								
Westinghouse. .	354	20½	922	40	427	23	1104	43
Widdifield and Button. . . .								

The absence of one or more of the brake companies will be noticed in the above tables. In the fifty (50) car train tests, with the buffer brakes, the stops with the American empty train showed conclusively that when the brakes on all the cars were used, the bumps and lurches at the rear of the train were so severe and numerous as to make the tests with the mixed and loaded trains dangerous. Of the three (3) runs attempted by the American brake with the fifty (50) car empty train, one was an utter failure, due to the application of the brakes before reaching the No. 1 stop post. It should be remembered that on the engine, after the required speed had been obtained, steam was shut off at a point some hundred feet before reaching the stop-post.

The Rote people had asked an extension of time on finding, by trial previous to the commencement of the regular tests, that their brake required re-adjustment. They did not enter the fifty (50) car tests for reasons which will be noted.

The Widdifield and Button Company, through mishap, were supplied with but twenty-five (25) cars.

The results of the stops with the twenty-five (25) car mixed train are as follows:—

25 Car Mixed Train.—Brakes on all Cars.

Name of Brake.	Stop 1.		Stop 2.		Stop 3.		Stop 4.	
	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.
American. . . .	547	22½	1633	39½	548	21	2774	40
Eames.	453	22	1477	40	485	20	2032	41¾
Rote.	1016	24	2341	36	1119	21½	*5566	40
Westinghouse. .	330	20	979	40¼	320	20	1490	45½
Widdifield and Button. . . .	500	21	1493	40	549	20	2781	43

The results of the runs with the twenty-five (25) car mixed train eliminated the Rote-brake as a competitor, the reduction of speed in the No. 4 stop showing conclusively that it was little if any more than that obtained from the use of the driver-brake.

The results of the driver-brake tests were as follows:

Driver-Brake Trials.—Engine, Tender and Dyn. Car.

Name of Brake.	Stop 1.		Stop 2.		Stop 3.		Stop 4.	
	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.
American. . . .	260	20½	889	40½	253	20	925	38
Eames.	335	20	1069	41½	387	21	1336	42
Westinghouse. .	363	21½	941	40	425	23	1331	41

* After running 4,114 feet beyond the point where the brakes were first applied, the train had a velocity of thirty (30) miles per hour. Hand brakes were then called for, and the total distance run in making stop was 5,566 feet. It is to be understood that the maximum power of the brakes was used.

No brakes were used on the dynamometer car. In these tests the results with the Eames and Westinghouse were obtained from the direct acting brake. The automatic driver-brake did not give as good results. As the total, and proportionate, weight of engines equipped with these three (3) brakes was the same, the results show that for an independent driver-brake the American type is the most efficient. It is also cheaper and simpler than either of the other two.

The third and last of the general tests gave some very interesting results. It was with trains of fifty (50) mixed cars to be let down a grade of fifty-four (54) to fifty-six (56) feet per mile, and two miles long, speed of twenty (20) miles per hour at top of grade, to be reduced to fifteen (15) miles per hour, and maintained without material variation throughout the run. The brakes were then to be applied and the shortest possible stop made. Of this test the Eames and Westinghouse companies had each three (3) runs and the American brake but one, as the latter showed very forcibly that brakes constructed on this principle were not able to control the speed of fifty (50) car trains safely, let alone satisfactorily, on grades of this magnitude. In the case of the Eames and Westinghouse brakes the best of the three runs of each are taken for comparison.

Graduating Test—Dropping Train down Hill—Train of 50 Mixed Cars.

Name of Brake.	Average speed of train.	Time consumed in making run		Max. speed after reduction to 15 miles per hour.	Min. speed after reduction to 15 miles per hour.	Dist. run in making stop from 207 mile post.	Speed at 207 mile post.
	Miles per Hour.	Mins.	Secs.			Feet.	Miles per Hour.
American . .	10.31	8	0	12½	8	3564	8
Eames . . .	15.88	7	35	20	12	1078	20
Westinghouse	16.52	6	45	18	12¾	693	14½

It is unfortunate that the distance run was not longer, say some fifteen (15) to twenty (20) miles, to show to what extent the

continuous brakes were able to control the speed of trains for this distance, and still retain sufficient storage power under the cars to enable an efficient stop to be made in case of an emergency. There are but few roads in the country that would not put a freight brake to this test in practice.

Let us review the last set of the general tests—that of dropping trains down grade at a speed of fifteen (15) miles per hour, or as near thereto as possible. The run was made from No. 3 stop post to 207 mile post, a distance of fully two miles. The engine was shut off five hundred (500) feet before reaching the No. 3 post, the train to have attained the required velocity at this point. The first attempt of the American brake to make this run resulted in the train coming to a dead stop after the engine had passed but a few feet beyond No. 3 post, the engineman having shut-off the steam at the five hundred (500) feet point—the train having attained the speed of twenty (20) miles per hour—thereby causing a slight retarding effect in the train and a positive and decided application of the brakes, which was far from being the result desired. In the second attempt to make the graduating test, some serious damage was done. The train, after running successfully about one and one-quarter ($1\frac{1}{4}$) miles, broke, either producing or caused by several vibrations, when it was found on examination that the loads, which consisted of cast iron car wheels, each weighing over five hundred (500) pounds and carefully blocked, had shifted and broken out the ends of six (6) or seven (7) cars which were not of light or weak construction, but rather the strongest cars at the test. This was the most serious defect found in the buffer type of brake as brought out by the Committee at these trials.

This ended the general tests.

The remaining, or special ones, will be considered with the principles of construction involved in the several brakes represented and the requirements of present railroad practice.

The requisites of a good railroad brake are:—

1st. It should be under the complete control of the engineman —that is, he should be able to apply it at any time, irrespective of any outside influences.

2d. It should be applied to every wheel of the train; that is,

when making a stop the braking should not be concentrated and violent, as is the case when not applied uniformly, but the brake pressure should be uniform throughout the train.

3d. It must be automatic; that is, the brakes should apply themselves in case of the train parting, or when any injury occurred to the apparatus.

4th. To obtain the maximum efficiency, the friction of the brake blocks against the wheels should closely approach, but not at any speed or load, equal the adhesion of the wheel upon the rail.

5th. The brake which is the most rapid of application—other things being equal—is the most efficient. For instance, a reduction of speed from fifty (50) to twenty (20) miles per hour, in a given time, is to be preferred to a reduction of from fifty (50) to thirty-five (35) miles per hour in the same time, even assuming that the distance run before coming to a dead stop is the same in both cases. For several obvious practical reasons this is a desirable point.

6th. The application of the brakes should take place simultaneously throughout the train. This is to prevent in long trains the concussion caused by the rear of the train running against the front or braked section, on account of the slack, by which violent shocks are produced.

The types of brakes represented at the Burlington tests may be divided into three (3) general classes:—

The direct buffer. (American and Rote.)

The friction buffer. (Widdifield & Button.)

The continuous brakes. (Eames Automatic Vacuum. Westinghouse Automatic Pressure.)

The direct and friction buffer.—The advantages claimed for this form of brake are lower first cost, maintenance and simplicity.

But we must not lose sight of the effect of a brake of this construction upon the general condition of the equipment. Any force tending to compress the draft spring after the car has attained a speed of ten (10) or more miles per hour, instantly applies the brake, the rear of the draft iron acting upon a piece of mechanism which is in direct communication with the brake beam. The application of the brake signifies that the elasticity in the

draft rigging is thrown out of action and prevented from relieving the effect caused by whatever concussion may take place between the cars. The result of these shocks upon the draft, brake-rigging and general life of the car will be material, while it will not necessarily influence the life of the brake proper. In this connection it is unfortunate the maintenance test will not include part of the general car repairs. Taking a mixed train of cars, loaded and empty, equipped with a buffer brake, and supposing the cars thrown in the train promiscuously. The action will be about this: the heavy sections of the train will tend forward, the light ones holding back, resulting in the application and releasing of the brakes, forming an irregular and interesting see-saw motion. This action is more perceptible when riding on trains of fifty (50) or more cars—loaded and empty—and decreases as the uniformity in the loading of the train increases and the length decreases. The irregular application exists, however, in all cases, as can easily be seen by an examination of a diagram showing the brake beam stresses of a buffer-brake when making a stop.

It has, therefore, been found necessary, where it is desired to perfectly control the train, that the application of the brakes should be positive, certain and independent of any but the proper influences; in other words, the application should be continuous throughout the train, as of a solid body, and when applying and releasing—alternately—upon independent cars is not only inefficient but dangerous in freight trains of ordinary length. More than this a buffer brake is not automatic, but on the contrary has no advantages over the ordinary hand-brake at points where trains generally part, as when coming out of a dip in the road. Even worse, it is likely to convey just sufficient confidence to make it an evil.

The two continuous systems represented at the trials—the Eames and Westinghouse—were found, throughout, the most efficient brakes. The results of the distances run in making the stops, while interesting, as showing what may be accomplished by a good brake, cannot fairly be used to make a comparison of the brakes proper. For instance, one of the companies equalized the brake leverage, while the other did not, which it is claimed

will increase the efficiency some eight (8) to ten (10) per cent. The methods of hanging the brakes were not the same; in one case they were attached to the body of the car, and in the other to the truck spring plank. The style of shoe, make of wheel and general train resistances were different, all of which would affect materially the results of the distances run, and it was for this reason, in the tables given, that they were not reduced, for the purpose of comparison, to the speeds of twenty (20), thirty (30) and forty (40) miles per hour. Of course, the advantages to be derived from car construction, method of hanging brakes and many of the other variables were open alike to both parties, but the question which railroad companies wish to have decided is a distinct one: which brake when applied to the freight equipment of any road will give the most efficient results, including first cost, maintenance, life of cars and general expense of transportation. This question can only properly be decided by placing the competitive brakes on the same cars at different times, and tried as nearly as possible under the same conditions of weather, road, etc. The distances run in making stops from the given speed would then show conclusively the efficiencies of the systems in this respect. It is for similar reasons that no mention has been made in a comparative way of the so-called "slideometer" measurements.

In comparing the Eames and Westinghouse runs, let us take the requisites of a good brake in the order before mentioned:

1st. Both types are controlled by the engineman—completely so.

2d. Either can be arranged to be applied to every wheel of the train. This was the case with the two trains representing these companies at the Burlington tests.

3d. As regards the automatic feature, both companies claim it, and the trials show that they can properly do so.

The following are the results of the tests to determine this point:

BREAK-IN-TWO TEST.—25 CAR MIXED TRAIN.

Eames Vacuum Brake.

STOP.	Speed at stop post when train parted. MILES PER HOUR.	Distance between two sections when stopped. FEET.	Distance run by first section. FEET.
1 A	22½	Together.	
2 A	36	423	
1 B	25½	150	
2 B	26½	25	
Westinghouse Automatic Brake.			
1 A	24	55	275
2 A	41	5	660
1 B	25	35	319
2 B	37½	Together.	627

In stop 1A with the Eames brake, the two sections came together with considerable force and did not part afterward. The other three stops were made under different conditions.

In the case of the Westinghouse—stop 2 A—the sections came together with slight shock before coming to full stop. In stop 2 B the sections came together with some force and did not separate afterward.

The trial was conducted in this way:—With the Westinghouse cars the engine was shut-off at five hundred (500) feet before reaching the stop post, when the coupling-pin connecting the two cars at about the centre of the train was drawn. On reaching the stop post the engine was pulled out and the brake-hose coupling between the two halves of the train broken. As soon as the engineman recognized that the train had parted, the engine was shut-off and the two sections allowed to come to a stop. This represented quite accurately the conditions as they exist in practice.

The first stop with the Eames brake was made in this way, but the two sections came together with such force that it was considered too dangerous to attempt at a higher speed. A special feature of this brake was used in making the other three (3) stops. The engineman watched the train gauge, and as soon as a reduction of vacuum was noticeable—after parting the train—the engine was shut-off and the large ejector thrown into action, by which it has been found that the brakes on a number of the front cars can be released. In this way the two sections were kept apart. But as the normal position of the ejector is with the small nozzle working, which has sufficient capacity to compensate for leakage, there are many chances that the engineman would fail to throw the large ejector into action in time to keep the two sections from colliding when considering the numerous other duties which he has to perform, and a failure to notice the gauge, or the parting of the train, at the proper time would render this feature useless. We cannot see, therefore, that this speciality is of much value; in fact, if it is necessary to use it on the parting of the train, the brake ceases to be automatic.

4th. The frictional power of the brakes can be as equally well proportioned in one case as in the other, but they cannot be arranged to exert the maximum frictional resistance for all loads and speeds without risk of skidding the wheels.

5th. In regard to the reduction of speed in the first unit of time after the application of the brakes. This question must for the present remain unsettled, as such of the diagrams from the centre car, from which it was expected to obtain it, are unreliable. The speed indicator was connected with the car axle by a wire belt which was found to slip.

Assuming the brake rod tensions in the two cases to be the same, and there is no reason why they could not be so proportioned, the rear car records give the other variable connected with this question.

50 Car Empty Train.

Name of Brake.	Average time from application of brakes on engine to when full-on rear car. Seconds.	Average time required to release brakes on rear car. Seconds.
Eames. . .	11¼	56
Westinghouse.	12½	46

These results are in favor of the Eames brake, as the matter of release is of less importance than that of application, and are quite the reverse to what was expected from the break-in-two test when in the first run the two sections came together with considerable force, which in the three (3) last stops was obviated by throwing the large ejector into action and partly releasing the brakes on the forward part of the train. The coming together of the two sections in the first run with the Eames cars may have been due to the system of brake rigging which, as noted, decreased the efficiency some ten (10) per cent. The rear of the train containing some seventy-five (75) per cent. of the loaded cars, this loss would be more marked in the break-in-two tests than in any of the others. It cannot be from the slowness in the application of the brake—if the above records are correct—nor are we prepared to say positively that it is not a defective feature of the brake.

In charging the cars equipped with the Eames brake, a vacuum of about twenty (20) inches is obtained. The action of the valve regulating the flow of air from train pipe to auxiliary reservoir is such as to allow a reduction of vacuum in train pipe to ten and one-half (10½) inches before the brakes will apply. The vacuum in the train pipe is so reduced after charging the train and any further reduction will apply the brake. This, combined with the use of a main pipe of large diameter, enables the vacuum in the main pipe to be varied as rapidly throughout a train as in the case of the pressure brake. In the Westinghouse system a reduction of twenty (20) pounds pressure is necessary before the brakes are full on. The sensitiveness of the triple

valves used in the two systems also enters as a factor in the time required for the brakes to apply. Both brakes admit of partial application.

In using either of the continuous brakes on a train of fifty (50) cars or more, the question of the influence of the slack enters, and it was found at the Burlington tests a sudden and full application of the brakes when the train was running at a speed of twenty (20), thirty (30) or forty (40) miles per hour, that the shock in the rear car was of more violence than could be allowed in practice. They were properly called emergency stops—meaning thereby, that the brakes were put on to their full power as rapidly as possible. It was found that by increasing the distance run some thirty (30) per cent., the train could be stopped without objectionable bumps. It can, therefore, be seen there are objections to placing the power contained in a continuous brake in the hands of enginemen, as when the evil results, which would arise by making quick stops, are not immediate and noticeable to them, the chances are that the power thus given them would be abused. It can also be seen that the reduction in life and increase of car repairs, destruction of perishable freight and cattle would be of some consequence. In this connection, trial trips were made with the Eames and Westinghouse systems with the brakes cut out of the cars in the rear of the train, the results of which were as follows:—

25 Car Mixed Train—Brakes cut out of Rear 13 Cars.

Service Stops.

Name of Brake.	Stop 1.		Stop 2.		Stop 3.		Stop 4.	
	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.	Dist'ce run in making stop. Feet.	Speed at stop post. Miles.
Eames	681	22	1814	31	964	21	3684	41
Westinghouse . .	968	26½	1652	41	960	26	2672	41½

25 Car Mixed Train.—Brakes cut out of Rear 13 Cars.

Emergency Stops.

Eames	615	22½	1872	41½	636	21½	3017	39½
Westinghouse . .	720	24½	1690	43½	666	24½	2056	40½

50 Car Empty Train.—Brakes cut out of Rear 20 Cars.

Service Stops.

Eames	544	21½	1213	36	614	20	1709	39½
Westinghouse . .	535	21½	1232	38	639	22	1238	39

Emergency Stops.

Eames	383	21	Was discontinued on account of broken draw-bars, etc.					
Westinghouse . .	379	21½	927	37	451	20	1077	37

A comparison between these figures and the ones obtained with brakes on all cars will show but a small loss in the efficiency of the stops, much less than would be supposed from the number of brakes cut out.

The force of the shocks in the rear car were reduced, but still too violent for general freight service.

A run with the fifty (50) cars Westinghouse train was made with the coupling link slack taken out, and it was found that with emergency stops the shocks in the rear car were much reduced, but somewhat above the objectionable point for stock and perishable freight.

This brought the subject of continuous brakes in connection with the coupler question, and it was conclusively shown that an engine by taking up the slack in both cases was able to start as heavy a train with close as with loose couplings. The results of this trial are unquestionable, and the settlement of the point involved, which has been hanging fire for so long, will resolve the many types of automatic car couplers, or so-called, into a few forms.

In conclusion, it is evident from the results that the continuous

brakes, when used on the fifty (50) car trains, contain the objectionable feature of the time required for the brakes to apply throughout the train, and that the first sixty (60) per cent. of the cars did from ninety (90) to ninety-five (95) of the braking. This non-simultaneous action of the brakes is open to several practical objections, all of which have been mentioned. The tests also show that there is no form of brake which meets the requirements of present railroad practice to the extent desired, yet it must be admitted, from a service test on several roads, that when a number of cars equipped with a good continuous brake can be used next to the engine that the efficiency of the service is increased.

The tests also show that there are two competing continuous brakes in the market, the automatic vacuum and the automatic pressure.

It is also evident that the coupler question, with or without link slack, should be taken up with that of a brake for long freight trains.

Note.—Referring to the extent of fulfillment of condition five by the continuous brakes at the trial, we note below some results which are taken from the diagrams obtained from the centre car. Inasmuch as with the pressure and vacuum brakes, the desired force to be exerted upon the brake beam can be varied by proper proportion of the cylinders, and as well by one or the other of the two systems, resolves the question of greater efficiency as regards this condition to the time required from the application of the brakes on engine to when full-on on any designated car in rear of train.

25 Car Mixed Train—Brakes cut out Rear 12 Cars.

Westinghouse Automatic Brake.

No. of Stop.	A.	B.	C.
1551	126	3.5	24½
1552	217	3.4	43½
1553	92	2.5	24½
1554	140	2.4	40½

25 Car Mixed Train—Brakes on all Cars.

Eames Vacuum Brake.

No. of Stop.	A.	B.	C.
361	80	2.2	25
362	108	1.9	38½
363	130	4.2	21
364	325	5.4	41

A=Distance run (feet) by centre car from time of application of brakes on engine to commencement (effective) of application of brakes on centre car.

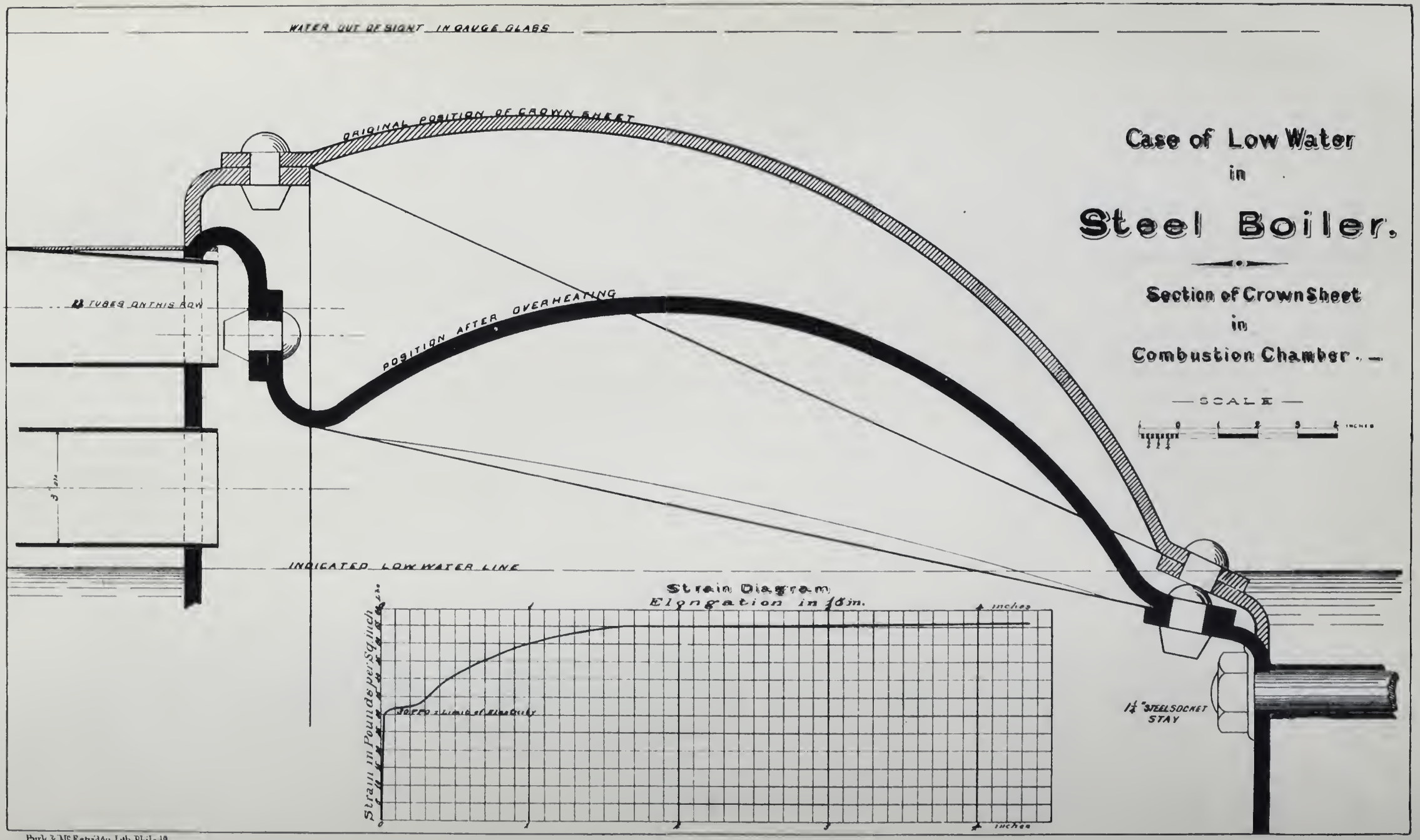
B=Time elapsed (seconds) from application of brakes on engine to commencement (effective) of application on centre car.

C=Speed of train when passing stop post.

The above results are the only similar ones we have at hand for comparison.

The figures in the third column (B) are derived by assuming the speed of train when passing stop post to be constant from that time until the brakes begin to apply on centre car, which, combined with the distance run, gives the *approximate* time before the brakes begin to effectively apply at the middle of the train. The wide variation of the figures in column B would go to show an error in the working mechanism used to give the diagrams from which these values were obtained, for which reason it was not considered proper, as previously stated, to compare the two continuous brakes by these results as to their meeting the requirement in question. In the settlement of points connected with a subject of so much importance, the recording of the results should be beyond question. The figures, while limited in number, are sufficient to show a too wide variation in the distances recorded by the mechanism in the centre car, to allow them to be taken when making a comparison of the efficiency of the brakes.

The distance run by the car from the application of the brakes on engine to the commencement of application on centre car, supposing the distances as recorded correct, are of no value in this connection, and should not be so given. The speed must enter as a function.



Burk & McFetridge Lith Phila.

The comparative figures to be obtained for the settlement of this point are, with a given train, the times required from the application of the brakes on the engine to when applied on the rear car, or to determine the brake that is "most simultaneous" in its application.

III.

A CASE OF LOW WATER IN A STEEL BOILER.

By J. E. Codman, Active Member of the Club.

Read October 16th, 1886.

An internally fired boiler constructed of steel plates and in constant use for about two and a-half years, was recently exposed to a very severe test of the material of which it was composed.

This boiler was 11′—6″ diameter, 10′—10″ long, contained two furnace flues 3′—6″ diameter, 8′—0″ long, and 188—3-inch tubes 7′—0″ long; the grate bars, bridge walls and fires are all inside the furnace flues.

Back of the furnaces is a combustion chamber 26 inches deep, the crown, sides and bottom of which is corrugated with corrugations five inches deep. No stays or braces are used to support this portion of the boiler, the corrugations being sufficient to strengthen this part to withstand the external pressure. (Sketch shows section of combustion chamber through crown sheet, and position of plates before and after overheating.) The highest point in the combustion chamber is three and a-half inches above the top of the upper row of tubes. Water line in the boiler is carried nine and a-half inches above the top line of tubes, making six inches of water over the crown sheet of combustion chamber to centre of middle gauge cock. Gauge cocks four inches apart, and with water shown in lowest gauge cock there are two inches of water over the highest point of corrugation in the crown of combustion chamber.

Fusible plugs are placed at those points to give timely warning of low water.

The glass gauge will show water about one inch below the bottom gauge cock.

The steel plates used in the construction of the boiler were all subject to a rigid test and inspection. The tests were made at the United States Arsenal, Watertown, Mass.

The material showed the following properties :—Tensile strength average, 53,000 pounds per square inch of section, elongation 31 per cent. in 15 inches, and 50 per cent. contraction of area. The accompanying sketch shows the strain diagram of the material. During the past summer the boilers were used to their full capacity night and day. By some oversight the water was allowed to fall below the upper row of tubes, exposing the crown sheet of the combustion chamber to the direct action of the fire with no protection whatever, and a steam pressure on the boiler of 60 pounds by gauge. The effect of this was to heat the plates composing the crown sheet, also the flange of the tube sheet to a high degree of temperature. An inspection of the boiler indicated that the water must have been near the bottom of the second row of tubes from the top. This water line was quite distinctly marked on the sides of the boiler. The steel tube sheet is $\frac{9}{16}$ inches thick, and flanged to the crown sheet and supports it at this side.

The back flange of crown sheet is riveted to the back sheet of combustion chamber, which is secured to the outside shell by one and one-quarter inch socket-stays with nuts and washers on both ends. This connection was partly exposed and overheated. The sheets on examination indicated by every appearance that the material had been exposed to a high temperature. The fusible plugs were all melted out.

The effects of heating the plates and the pressure of 60 pounds of steam on the outside, was to force the crown sheet down by the yielding of the tube sheet, until the rivet-heads in the flange struck the tube ends, the flange at the back connection following as far as the upper row of stays would allow it to bend over, and being under water the strain could not pull the heads through.

The corrugations did not change their form to any great amount, and remained intact.

Those in charge of the boiler, not fully realizing how low the

water was in the boiler, put the feed pump on and filled the boiler almost immediately up to the regular water-line. This of itself would be considered a pretty severe strain on any material, but with steel plates it seems almost incredible that the plates did not crack.

Owing to the leaking of the tubes and the quantity of water flowing from the fusible plugs it was considered advisable to shut the boiler off and draw the fires.

On examining the sheets, it was found that the tube sheet showed no signs of cracking. It was taken out, the flange bent back into position, and it is now working at the usual pressure of 60 pounds, as good as ever it was. From the severe test this material stood, it seems that steel plates for boiler use, as at present manufactured, are capable of standing a good deal of rough usage, either from carelessness or accidents.

IV.

EARLY MINING OPERATIONS IN BERKS AND CHESTER COUNTIES.*

By J. H. Harden, Active Member of the Club.

Read October 16th, 1886.

These records of the early mining operations for iron ore go back to the year 1836 (50 years). The furnaces represented by the "Mining Company" were as follows:

Warwick,	Chester Co.,	built	in	the	year	1736
Hopewell,	"	"	"	"	"	1759
Isabella,	"	"	"	"	"	
Joanna,	Berks	"	"	"	"	1794
Mount Penn,	"	"	"	"	"	1827
Phœnixville,	Chester Co.	"		"	"	1845
Hampton,	Berks Co.,	"		"	"	1846
Monroe,						

*Notes collected from the minute books of the "Mining Company" in the possession of the Hon. John T. Potts and other sources.

It appears from the dates given mining has been carried on 150 years, although the operations hereafter referred to go back only 50, and cover a period of 21 years, up to 1857. Mr. John T. Potts tells me, however, that earlier records were in possession of the family at Warwick, until they became such an incumbrance as to be doubtless destroyed at house-cleaning times. At the present, only one of the furnaces (Joanna) is in blast in its original shape under the management of the proprietor, Col. L. Heber Smith. Hopewell and Hampton were in blast within the past five years. The principal locations referred to are the Jones mine, near Joanna Station, on the Wilmington and Northern R. R., and Warwick mine, Warwick, on the St. Peter's branch of the same road, the former in Berks the latter in Chester county, distance apart some three miles, on what is known as the "Warwick Furnace" lands, 52 tracts, containing 10,925 acres. The right to dig iron ore belongs at the present time to five firms or individuals in different proportions, any one of which may dig ore, but is required to answer for all taken away in excess of his or their proportion to the other owners at the rate of 50 cents a ton.

The "Mining Company."

It was the custom of the Mining Company to meet once a year or oftener. At the first meeting, April 4th, 1836, Messrs. Potts, Brooke, Rutter, Smith and Schwartz attended, when the quantity of ore ordered to be mined during the season, from the Jones and Warwick mines, was as follows:

	Jones.	Warwick.	Washed.
Warwick Furnace, . .	1,500	——	——
Isabella " . . .	1,600	600	400
Hopewell " . . .	1,000	——	——
Mount Penn " . . .	2,500	100	——
Kiems & Co., Monroe Fur.	1,500	——	——
Joanna Furnace, . . .	1,200	450	——
	9,300	1,150	400

Mr. Wm. McIlvain, the manager (now President of the Second National Bank at Reading), was directed to ascertain whether the "wash dirt" kept separate last year is worth the cost.

At this time miners' wages were from $18 to $20 per month, and the ore raised by contract cost $1.25 to $1.50 a ton. A strong boy with horse and cart was worth $1.25 a day.

May 2d, 1836. The Company directed the payment of Mr. Lloyd's bill for tunneling at "Steel's Mine," where 77 yards had been driven at a cost of from $2 to $15 per yard, and the location was abandoned. On the same date, $548 was paid for 125 yards of work at Jones' mine.

August 1st, 1836. Mr. McIlvain was ordered to get an auger and bore for ore.

October 3d, 1836. The Company directed the "coppery ore" should be kept separate and mining to be conducted to avoid it.

April 3d, 1837. "The Company find great fault with the coppery ore."

June 5th, 1837. Ore ordered for the season:

	Jones.	Warwick.
John Schwartz, Mount Penn, ...	1,500	300
Clement Brooke & Co., Hopewell, . .	500	——
Smith & Darling, Joanna, ...	1,000	350
H. & D. Potts, Isabella, ...	1,200	1,000
Kiems, Jones & Co., Monroe, ...	1,500	——
D. Potts, Warwick, ...	1,200	350
	6,900	2,000

January 8th, 1838. Clement Brooke was elected President, and John Schwartz Secretary of the Company. Mr. McIlvain to get a pump to go by steam or horse-power for "Warwick mine holes."

February 5th.—Robert T. Potts appointed Manager at the "lower mine holes" (Warwick) at $1 per day, Sundays included, to commence as soon as the season permits and to continue one year. During the season the several furnaces required 7,000 tons of Jones and 4,000 tons of Warwick ore.

During the year 1839 Mr. R. S. Potts was continued as Manager, at a salary of $500. The improvements at Warwick were valued at $637.75; miners' wages, $20 to $22 per month; 2,600 tons of ore washed by the Company cost $1.45 per ton; 1,400 tons by contract cost $1.25 per ton.

Ore required by the several furnaces for the season, 6,600 tons from Jones' mine and 3,400 tons from Warwick.

October 9th, 1839.—Mr. R. S. Potts directed to search for ore at Warwick and allowed to spend $200. *Nov. 4th.*—An additional $100 was allowed for the same purpose.

April 8th, 1840.—Ore required for the season from Jones' mine, 2,400 tons; from Warwick, 7,100 tons.

January 12th, 1841.—Messrs. Reeves & Whitaker were admitted into partnership on payment of one-seventh of the value of the stock ($1,350), afterwards changed to one-sixth share. Ore required for the season from Warwick, 2,500 tons; from Jones, 6,800 tons, the Phœnixville furnaces taking 700 of Jones, and 500 of Warwick ore, all of which was hauled by mule teams, an average distance of 18 miles.

January 1st, 1843.—Jonathan Sidle admitted to the Company on payment of one-seventh for machinery, tools, etc., and the same amount for finding the "Red ore" at Jones' mine; total, $575.04. The furnaces require for the season from Jones' mine, 5,000 tons; Warwick, 4,150.

February 6th, 1844.—Resolved that each furnace contribute $12 towards paying the expenses of searching for ore at "Steel's mine."

April 2d, 1844.—Complaints of the mine water running into the streams.

Ore required for the season from Jones' mine, 4,400 tons; Warwick, 6,350; 1,600 tons of which went to Phœnixville.

December 3d, 1844.—Mr. Wm. McIlvain resigns the management of Jones' mine, and Mr. Hartley Potts appointed from April 1st, 1845, at a salary of $550. Mr. Robert Potts continued at Warwick at a salary of $550. "Resolved, that the Company tender their thanks to Mr. McIlvain, for the faithful manner he has discharged his trust, and that the Company is fully satisfied with the manner the business has been transacted; further, that each member testifies the same by his signature."

(Signed by)	David Potts, Jr.,	Jonathan Sidle,
	Clement Brooke,	David Potts,
	Levi B. Smith,	John Schwartz.

January 4th, 1845.—Ore required for the furnaces from Jones' mine, 4,200 tons; from Warwick, 11,600 tons.

April 8th, 1845.—"Resolved, that the property at the Warwick mine, lately purchased from Geo. Miller, be held in equal shares and the title be made in trust to Robert S. Potts for the Mining Company." Messrs. Reeves & Whitaker protest against their order of 2,500 tons of ore from Warwick (the nearest location by three miles to their furnaces) being cut down to 1,500 tons.

October 7th, 1845.—Three or four acres of land purchased from Frederick Ray, for the use of the Mining Company.

April 7th, 1846.—Members of the Company present: Messrs. Brooke, Smith, Buck, Ed. Brooke, R. Potts and J. Schwartz. Ore required for the season from Jones' mine, 9,900 tons; Warwick, 8,900 tons.

May 5th, 1846.—Robert T. Potts to purchase a lot of ground for a dam (mud dam), from James Catter.

November 3d, 1846.—Robert T. Potts to search for ore at the Warwick mine holes and to continue as Manager.

December 1st, 1846.—Damages to the lands of Jacob Filman and Frederick Francis, to be settled on the best terms attainable.

Hartley Potts to continue as Manager at Jones' mine for another year.

April 5th, 1847.—John Schwartz directed to settle the accounts of Hartley Potts for the year ending April 1st, 1847, as follows:

Dr.	Hands employed as Washers, Carters, etc., .	$3,057.95
	Carts and hands, ...	1,699.14½
	General charges, ...	2,159.28
		6,916.37½
Cr.	Smith work, ...	76.56
		$6,839.81½

Cr. 5,600 tons of ore at $1.22⅛, delivered to the furnaces as follows:

Mount Penn.,	1,100 tons,	$1.22⅛	$1,343.37
Phœnixville,	800 "	"	977.00
Monroe,	420 "	"	512.92
Isabella,	280 "	"	341.95
Warwick,	800 "	"	977.00
Joanna,	650 "	"	793.81
Hopewell,	650 "	"	793.81
Hampton,	900 "	"	1,099.12
			$6,838.98

Ore required for the season from Jones' mine, 11,400 tons; from Warwick, 5,200 tons.

November 2d, 1847.—Horse-power and iron pump to be placed at Jones and at the same time at Warwick mine.

December 7th, 1847.—Managers continued and the pumps to be kept running until ore raising begins.

April 4th, 1848.—Ore wanted for the year from Jones' mine, 12,900 tons; from Warwick, 4,300 tons.

December 5th, 1848.—Managers continued for the coming season's work. Mr. Potts to engage an "under-manager" for the Jones' mine. The expenses in search for ore to be paid by each furnace in proportion to quantity received.

February 13th, 1849.—Peter Ubil to have charge of the old mines, and John Kenny of shafts and drifts, subject to the "head manager," Ubil to receive $500 per annum and Kenny $8 per week.

April 3d, 1849.—Pump-house at shaft and drift to be enlarged and the power increased. The Company to dig a well in such a place as Mr. H. Potts shall direct. The ores and mining accounts to be kept separate. Ore required for the season from Jones' mine, 8050 tons; from Warwick, 3,900 tons.

November 6th, 1849.—Resolved to purchase an engine of ten or fifteen horse-power for Warwick mine, also one for Jones' mine, to be put up next season or the season following.

December 4th, 1849.—Robert T. Potts continued as manager, salary, $550; Hartley Potts, $400, and Peter Ubil, as under-manager, at $400.

February 5th, 1850.—None of the Company to be allowed over 2,500 tons of ore for the season. Warwick furnace to have 3,500 in consideration of advantages received from Mr. D. Potts.

Ore required from Jones' mine, 8,100 tons; from Warwick mine, 4,250.

June 4th, 1850.—Give orders to wash the "body mine" that requires it.

November 5th, 1850.—Hartley Potts to inquire about a second-hand engine there is for sale at Reading.

February 4th, 1851.—Ore required for the season from Jones' mine, 7,800 tons; from Warwick, 4,300 tons.

May 6th, 1851.—The manager at Warwick mine is ordered to open a shaft 450 feet north-east from the present shaft, to be unwatered by a connecting rod attached to the engine.

December 16th, 1851.—John Schwartz sold his interest in the Warwick mine (except the land) for $300, with permission to re-enter at any time by repaying that amount and for the improvements.

Robert T. Potts contracts to raise from the Warwick mine 3,500 tons of ore, at $1.37½ per ton, the Company to remove and put the engine in order. Mr. Potts agrees to work in a skillful manner and take out all the ore as near as practicable; to break the ore ready for loading in frosty weather; to keep all tools belonging the Company in good order; also, the engine and hoisting gear, pumps, etc. In case of foul air in the mines, the Company agree to furnish the means for getting it out.

"*Resolved*, That David Potts & Co., of Isabella, be paid $300 by those operating at Warwick mine, for all their interest, except their share in the lands." "Those of the Company operating at Jones' mine, to pay $300 for the interest held by them (D. P. & Co.) at that place."

Hartley Potts contracts to raise ore at Jones' mine for $1.37½ per ton. Ore ordered for 1852, from Jones' mine, 4,200 tons; from Warwick, 3,700 tons. Reeves, Buck & Co. ordered 508 tons from Warwick, not having had any since 1848.

July 6th, 1852.—Want a new working barrel for the small pump at Warwick mine.

December 4th, 1855.—Hartley Potts continued as manager at Jones' mine, and Frederick Richards appointed to succeed

Robert T. Potts at Warwick, salary $450 per annum, and the same privileges Mr. Potts had.

February 15th, 1856.—Mr. Kaufman to have one-fourteenth interest in the present shaft, to be taken from Mr. Potts' interest in the same. Expenses to be settled by them. Frederick Richards instructed to increase his force and take out 50 tons daily. To employ hands to gather "top ore" at $2.00 per ton.

March 4th, 1856. Agreed to move the engine at Jones' mine.

January 6th, 1857. The Company agree to continue the present managers. Mr. Kaufman allowed to sell his interest in the Warwick mine to Dr. Clingan.

Upon a loose slip pinned to the cover of one of the minute books is the following record:

Date.	Tons mined.	Cost per ton.	Total cost.
1836	6,668	$1.06	$7,068
1837	6,772	1.25	8,463
1838	7,000	1.10	7,700
1839	6,600	1.00	6,600
1840	7,009	1.05	7,359
1841	6,800	1.00	6,800
1842	5,350	1.05	5,617
1843	4,000	1.09	4,000
1844	5,000	1.00	4,000
	55,199 tons.		$58,607

Surplus ore	10,000 tons
Mined	55,199 "
Total, ...	65,199 "

Cost $58,607=90 cents per ton.

In search of further information relating to early mining operations, I received the following letter through my friend, Mr. Samuel Wynn, Phoenixville.

HARRISBURG, August 31st, 1882.

SAMUEL WYNN, Esq.

Dear Sir:—I have scarcely anything in my possession in regard to the "Pennsylvania Copper Company." This all had taken

place before I was born. From a memorandum book of my dear father's, I find Captain Henry Thomas was manager and cashier. Captain Thomas was from Falmouth, County Cornwall, England. The mine (Jones' mine) must have been opened the beginning of the year 1805, as my dear father arrived in the spring of 1806, as smelter of ores for the company. Captain Thomas died May, 1808. Then my father, Richard Trewick, was elected manager and treasurer of the Company. It was in existence it appears from 1805 to 1811, not proving productive was sold out by the sheriff. If the stock book is in existence, it must be in the hands of the late W. P. Hobart, Esq., of Reading, or, perhaps, the Potts family.

My father, Richard Trewick, came from Falmouth, County of Cornwall, England. I have no documents of any kind in my possession that would give any further description of the mine, they being all destroyed by my father's removal to the west. I heard my father say they worked their engine with wood and it cleared off acres of it and made the works very expensive.

The great difficulty has always been to extract the copper from the iron, they being of the same weight (specific gravity.)

Very respectfully,

W. L. Trewick.

The following very interesting letter was received from Mr. Wm. McIlvain, President of the Second National Bank of Reading, (formerly manager of Jones & Warwick Mines), in answer to my inquiry for information:

Reading, Pa., October 5th, 1882.

John H. Harden, Esq.

Dear Sir:—I don't see that I can give you any information in regard to Jones' mine that will be of service to you; if I could I would gladly do it.

About January, 1836, the Iron Masters getting ore there formed a company, "The Berks & Chester Mining Company," and employed me as manager. I was there until 1845. Previous to my going there, each furnace had raised their own ore; there was no system, no regular opening; they would dig a hole and throw the ore and dirt up with shovels and pump the water by hand.

When I commenced I was directed to cast the dirt entirely out of the way and put in horse pumps. We then had an opportunity of seeing what there was there. At that time the ore was used chiefly for charcoal furnaces, the copper and sulphur ore was selected from the good ore and deposited in large heaps on the bank, which was afterwards used up by separating the iron from the copper by magnets. There were some beautiful specimens of copper ore taken out by a Mr. Simons. While I was there I invented a washing machine and used it all the time I was there; it paid the company well. Afterwards, John Milholland, of this place (Reading), put two in one trough and had it patented. I see them used now quite extensively. We had two running by H. P. If I can give you any information that will be of use to you, I will gladly do it. Mr. Joseph Whitaker was the gentleman from Phoenixville who attended the mine while I was there.

Yours truly,

Wm. McIlvain.

This letter is important as identifying the inventor and first use of the "log washer," built from timber 10 to 15 feet in length, and 9 to 12 inches diameter, into which blades (blade shown) of wrought iron were driven at intervals in its circumference and length, forming a rude sort of propeller. This was supported in journals at each end, revolved in a water-tight trough, both slightly inclined. The "wash ore" was fed at the lower end, the water at the upper, and the revolutions of the propeller moved the material in the box in the opposite direction to the flow of water, carrying the heavier and coarse material out at the upper, while the water carried the dirt and mud out at the lower end. Coarse refuse had to be picked from the ore after being washed. Such a machine was used at the Kenny mine, near to Jones' mine, within the past five or six years, by Mr. H. Harvey, who was at that time mining for Col. Smith. It was driven by horse power, and answered every purpose of washing the limited amount of ore mined.

The invention referred to by Mr. McIlvain as having been patented by Mr. Milholland, of Reading, was a combination of two such propellers, revolving in opposite directions, in the same trough, a much more effective machine for washing the clay

from hematite ores. The Carter washer is another modification of Mr. McIlvain's invention. It is a wrought iron cylinder, 10 feet long, three feet diameter at one end, and six feet at the other; the blades are riveted inside, the ore is fed at the large end, the water at the small end.

The following letter was received from Mr. Nicholas Jones of Reading :—

READING, Oct. 3rd, 1882.

MR. JOHN H. HARDEN,

Dear Sir :—Your communication was duly received, making inquiry in regard to the early mining at Jones' mine. I regret to say that I am unable to give you any information on the subject. Our family had no title in them, except one small share, purchased about 1830, in order to obtain a right to mine ore for the use of Winsor and Schuylkill furnaces. Mr. William R. McIlvain was engaged to attend to the mining operations.

Most respectfully yours,

NICHOLAS JONES.

The name Jones was derived from a Welsh family. David, born in Wales in 1709, died in 1784. His son Jonathan took out a patent for the Jones mine tract of 39¾ acres, December 22d 1773, when it was known as "Jones' good luck," and sold the same to Mark Bird, February 14th, 1774. Jonathan was born in 1738, and died in 1782. Mineral, copper or iron was evidently discovered by one or other of these men. It was not unusual to own land in those days without a patent, and the discovery would lead the owners to protect their property by patent. Again, the sale to Mark Bird was made two months after the patent had been granted, and probably the title was perfected for that purpose. We find no authority for the date of the arrival of David Jones in America, but there is a probability of his having been brought over to work in the iron works, as we find he would be 27 years of age when Warwick Furnace was built. We have no certain record of the use of this ore for iron working until a much later date.

From the records of Berks County Court we find, as early as 1801, the eastern boundary of the property was in dispute, and an amicable action was entered into by the respective owners

—Joanna Potts, Martha Rutter and Sarah May, the owners of the Jones mine tract as plaintiffs, and Daniel Buckley, Thomas Brooke and Matthew Brooke, the adjoining owners, defendants. This difference was, by consent of all parties, referred to Robert Coleman, Benjamin Marclay, John Ralston, Patterson Bell and James Gibbons, Esqs., or any three of them. December 10th, 1801, the referees submitted their report establishing what has been known as the "compromise line." At the end of 56 years all trace of this line was lost, and in 1857 Clement Brooke and Ed. S. Buckley, being the owners on one side the line, brought suit for trespass against David Potts, Jr., the owner of the land on the opposite side the line, averring that said Potts had mined across the boundary, and had taken 15,000 tons of ore, of the value of $7,000. The trial resulted in a verdict for the plaintiffs for $1024 and costs. The defendant carried the case to the Supreme Court, where the decision of the lower court was reversed. Here the matter rested until 1882, when all the parties in interest agreed that Messrs. Kendall Brothers of Reading should locate the disputed line. This they did November 3, of the same year.

At the present time the mine is operated by the E. & G. Brooke Iron Co., Birdsboro, and the Phœnix Iron Co., Phœnixville, in partnership, the former taking 40 per cent., the latter 60 per cent. of all the ore mined, and paying the expenses of mining in the same proportion. In 1880, 1881 and 1882 there was mined 37,000 tons. During the last four years the mine has been idle; now we are pumping out the *water* preparatory to resuming active work. There is no difficulty in obtaining all the ore required by the two companies, to the extent of 20,000 tons a year if necessary. The cost of mining is somewhat less and wages paid more than in former years. The location, looking to a continued supply of ore, is considered by those best able to judge a valuable one. A topographical map representing the mine will be found in the atlas to Report D^3 of the Second Geo. Sur. of Pa., and a model of the same was exhibited to the Club some time ago.

The ore is a magnetite, containing about 46 per cent. metallic iron.

The Warwick mine is at present operated by the E. & G. Brooke Iron Co., Birdsboro. The locality has been thoroughly explored by them and the Phœnix Iron Co., and is not now considered of much value as a producer of ore. Like the Cornwall, Boyertown and the French Creek ores, the Jones and Warwick contain "sulphur," and require roasting. They have the advantage, however, of low phosphorous, rendering them suitable for the manufacture of Bessemer iron, for which purpose the E. & G. Brooke Iron Co. will manufacture pig for their new steel plant.

V.

HORIZONTAL TURBINES IN WILLIMANTIC.

By John Graham, Jr., Active Member of the Club.

Read October 2d, 1886.

Having had the opportunity to observe the construction of the Horizontal Turbines for the Willimantic Water Works, I have thought that a brief description of them would be of interest to the members of the Club, particularly to those engineers connected with hydraulic work.

Turbines as generally constructed are placed on vertical shafts: the motion received from the water being transmitted to the work for which the power is to be used, by means of jack or line, horizontal shafts with bevel gears.

This class of Turbines when rightly constructed, with the proper superstructure and gearing, is usually reliable, and is used, of course, extensively.

Nevertheless the necessary complication of the gearing left something to be desired, also; the pressure of the water and the weight of the revolving part of the Turbine produces an amount of friction, which, besides absorbing power, causes interruption and expense in the removal and replacement of the "step" upon which the Turbine revolves.

Again, the position of a set of Turbines can often be more eco-

nomically and satisfactorily located where the surrounding conditions admit of their being placed horizontally.

Owing principally to the difficulty of transmitting altogether reliably and economically the motion of a Turbine revolving at a great velocity—such as is the case of Turbines operated under a high fall of water—horizontal Turbines, or to speak more correctly, Turbines placed on horizontal shafts have been made before to a limited extent.

In the case of the Willimantic Turbines, the application is to a comparatively low fall of water—nineteen (19) feet—in fact, judging from actual operation of the Turbine arrangement, this summer, its action with a reduced fall of fifteen (15) feet was so satisfactory as to surprise the Water Commissioners.

The arrangement at Willimantic consists of two (2) sets of Turbines, each operating two (2) pumps: the Turbines placed upon connected horizontal shafts revolving in cast iron casings, to which the water is admitted through wrought iron inlets six (6) feet in diameter.

The special features of this Turbine arrangement are as follows: two (2) movable or revolving wheels, the blades of which are bronze, are forty-four inches in diameter, and are secured to a horizontal shaft placed nine (9) feet above the tail water or lower level. They are made to turn to the right and left, but placed in such a manner in relation to each other as to cause the shaft to revolve by the action of both Turbines. The mechanical arrangement is such as to admit (by simply removing six coupling bolts) of operating the pumping machinery with one Turbine.

In this case the end thrust caused by the want of counter action of the second Turbine is taken up by glass discs surrounded with oil.

Another feature is the mode adopted for controlling the action of the water by means of sliding gates placed in front of the guide wheels.

Looking over records of Jonval Turbines constructed, with the exception of "Geyelin's Duplex Jonval Turbines," it will be found that the gates heretofore used were placed below the Turbines, very often at the outlet of the draft tubes, requiring for proper construction a foundation-plate resting upon a planked floor.

The advantages of these sliding gates controlling the *inlet* of the water instead of the *outlet* are marked. They are: first, the greater simplicity of the construction of the wheel-pit, requiring no planked floor, often very expensive to place owing to the presence of water. Second, a more economical action of the water when contraction becomes necessary in the flow through the Turbine, caused by either want of water or want of sufficient resistance in the machinery to be propelled. Third, greater simplicity in construction, consequently greater reduction of cost.

The speed of the Turbine shaft when operated under nineteen (19) feet fall, is one hundred and five (105) revolutions per minute.

The motion of the Turbine can, by the shifting of an open pinion, be transmitted to either set of pumps.

The general arrangement of the Willimantic plant was given by Mr. J. F. Fanning, H. E., and constructed and put in operation by the Camden Iron Works, from plans furnished by Mr. E. Geyelin, whose work is so well known in this country.

Accompanying this description will be found a small wood-cut, which exhibits graphically the position of the pumps and Turbines, as well as a drawing showing the construction and position of the movable wheels in the casing.

VI.

CAR LUBRICATION.

By W. E. Hall, Active Member of the Club.

Read November 6th, 1886.

What will be the result of the many attempts to improve the present condition of car lubrication and to overcome some or all of the various annoyances, particularly that of the heating of journals and brasses, which are now connected with this important part of the transportation and motive power departments of railroads, is a matter of great interest.

The distinction between good and bad lubrication is simply a comparative one, but the efforts should always be directed toward

reducing the frictional resistance, wear of journals and bearings, the combination of which with the quantity and quality of lubricant required per car per mile should be taken when it is desired to obtain the most economical practice. For instance, it is frequently argued that the wear of bearing metal per journal per unit of distance run is the one important consideration, and the metal which gives the minimum abrasion for this unit of service —results from a large number of tests—is the best. But there is another wear going on at the same time, that of the journal, and with this it will be remembered that when but a small part of the journal is worn off it is necessary to scrap the whole axle. It is but proper that this point should be taken into consideration, for while the bearing metal may be giving the best of service as regards low percentage abrasion, the journals may, at the same time, be rapidly wearing away, and the efficiency of the car service, therefore, not what it should be.

It is often asserted that the softer metals when used for bearing purposes will wear journals more rapidly than will the harder ones. This is claimed from the amount of foreign matter which becomes imbedded in the softer metal and which produces a grinding action upon the journal. Car oil boxes are very imperfect dust-excluders and this point may be of some importance, but with stationary engines, and especially with high speeds, the general practice has been in favor of the softer metals. No results have ever been seen to verify the general opinion of the effect of soft metals when used for bearings upon car journals and, as far as known, the results are simply surmised. We do not believe that in car work the softer metals are as injurious to journal wear as are the harder ones.

Practical requirements alter somewhat the conclusions previously drawn in regard to the comparative wear of journals and bearings to obtain the most economical results. It is still considered proper that axles should be withdrawn from service after having made a given mileage, as it is still supposed that the metal—steel or iron—deteriorates and is unsafe after this given service. With this in mind the bearing metal should be selected such that the wear of the journal from the maximum to the minimum diameter would take place when the axle had made the

given mileage. The bearing metal which will meet this requirement, and at the same time give the minimum abrasion with cost, would be the most economical. The points of liability to heat and lack of uniformity in mixture are, of course, to be eliminated before the abrasion and cost are considered, as they are such as influence the expense and difficulty of conducting transportation to an extent which should be prevented when it is possible.

Economic railroad practice requires the consideration of these matters, and the combination of all such as to give the most efficient results is desirable.

In this connection the lubrication proper enters to influence the wear of both journals and bearings.

The method of lubrication which is now used for passenger and freight car journals is somewhat imperfect at its best, and much more so as carried out in railroad work. The principle of its action is that the material used in the boxes, whether fibrous, cotton or woollen waste, is of such a nature as to retain and, it is claimed, draw oil from the bottom of the oil box to the journal with which it is in contact, kept so by packing it sufficiently tight in the boxes that the elasticity of the waste will thus retain it in position. There are then these points claimed for the material used in packing the boxes with this method of lubrication; it has elasticity, and the capillary property is of such strength that it will not only retain but actually draw oil from the bottom of the box to the journal. As to what extent the fibrous, cotton or woollen waste meet the second claim, a simple test will be sufficient to convince a person. Take, for instance, a small amount of dry woollen waste, this having the strongest capillarity of the three, and place one end in a large cup half filled with oil, allow the waste to pass over the side of the cup and the second end to rest upon a table. After some twenty-four (24) hours thus standing the waste will be found to be more or less oily to the touch, and more than likely an oil-spot will be found upon the table where one end of the waste has been resting. From such a test the amount of oil, mineral, which woollen waste had thus absorbed after some three (3) or four (4) days in this condition, was not much more than noticeable, and certainly far from being sufficient to lubricate a car journal. The waste appeared to reach

the maximum of absorption after twenty-four (24) hours; that is, no increase in the amount of oil absorbed was noticeable by a duration of the test beyond this time. In this case the conditions rather favored the waste, as the fibre was placed so as to be continuous from the cup to the table, which is much better than that found in practice.

As it is evident, then, that the capillary property goes for naught, the next best point with the method of lubrication in question is the power of the packing material to retain oil, by which that in contact with the journal, when oil is poured upon it, will be in a good condition for lubrication.

From the manner of attending to car boxes it is found that the waste from the frequent but small doses of oil which it receives does not reach its best condition, that is, the waste thoroughly saturated when the upper part, or that next to the journal, is able to retain a larger percentage of oil, until after it has made considerable mileage and then it is that the lubrication of the journal obtained by this method is the most efficient. So it is that new waste when put into boxes will always make the journals reach a higher "running heat," which although advantageous as increasing the fluidity of the lubricant and, therefore, decreasing the co-efficient of friction, yet is objectionable as reducing the condition of lubrication to a more sensitive one, and more likely to influence the production of hot journals. For this latter reason a low "running heat," of say seventy-five (75°) degrees Fahrenheit, while giving a somewhat higher frictional resistance, is desirable.

It is always advisable to saturate new waste as thoroughly and as long as possible before placing in car boxes and to use waste for repacking, and when it does not contain sand or grit that has seen more or less service.

It will then be noticed in the present method of lubricating car journals, that immediately after the box has been oiled, the top of the waste is well saturated and all in good condition but a short time will dry the waste in contact with the journal of whatever oil it may contain by its falling to the bottom of the box, dissipation and leakage at the mouth and back. While the box may contain abundance of oil at the bottom, the top of the waste,

where it is desired the oil should be, is comparatively dry and inefficient. In this connection a mixture of cotton and woollen waste—half and half—is found to give better service than either used alone. The woollen waste has the elasticity, and the cotton waste, while not absorbing as well, seems to keep the oil in the desired position better than does the former. This is due to the cotton packing closer and tighter than does the woollen waste.

The recent experiments of Mr. Beauchamp Tower have thrown much light upon the subject of lubrication. Three methods of lubricating were tried, and it was found that the oil-bath under the journal gave by far the most efficient results. With the several methods the comparative frictional resistances were:

Oil bath	1
Pad saturated with oil under and in contact with journal	6.48
Syphon Lubricator	7.06

The syphon lubricator was placed in the bearing at a point where the maximum pressure was exerted, in the centre line, and showed conclusively after many trials that such a method of lubrication, with even much lower pressures than used in car work, was next to useless. These figures are rather surprising, and show beyond question, from the reliability of the experiments, that the attempts to improve the manner of lubricating car journals should be directed toward the use under the journal of an oil bath, or its nearest practical approach.

It is not intended, however, to discuss now the experiments referred to, but it is hoped an opportunity will enable an early presentation of a paper upon the general subject of car lubrication for discussion by the members.

It is thought that sufficient has been said to show the crude and inefficient condition of the present method of car lubrication; the practical reasons for so concluding can be more forcibly shown by figures at some meeting in the future.

It is surprising to see the amount of scepticism which exists in regard to this subject and among those who have had the most

extended experience, which, probably, has been brought about as much by the numerous unsuccessful "rattle-traps" that have been designed and constructed for the purpose of accomplishing the lubrication of car journals as from any other cause.

VII.

FATAL ACCIDENTS IN ANTHRACITE MINES.

By Frank A. Hill, Active Member of the Club.

Read November 6th, 1886.

The dangers of anthracite mining are manifold, a detailed history of its accidents would be one of mixed carelessness, heroism and seeming fatality. During the year 1885 the community was startled by the accounts of three accidents by which forty-two lives were lost; one at Mocanaqua, Luzerne County, August 11th, by which ten men were suffocated; one at Plymouth, Luzerne County, October 21st, by which six men were burned to death, and one at Nanticoke, Luzerne County, December 18th, by which twenty-six men were buried by quicksand.

These unfortunate occurrences, with all their sad surroundings, thrilled us with horror, while the papers, with their accustomed energy, fed us with sensational descriptions which were digested without regard to their truth or accuracy. The fact of the loss of these forty-two lives, however, stands. This record of death is truth.

These fatalities succeeding each other so closely, and stamped on the public mind with all the impressiveness of reporters' rhetoric and of editorial criticism, have given the impression that our anthracite accidents are rapidly increasing, and that the life of the miner is little considered.

The duty of mining engineers and superintendents is to obtain the greatest yield at the least cost of money and life. That our yield is more than sufficient to meet the demands of the market is proven by the existence of the coal combination with its restriction policy. That our system of working is growing better and more economical is shown by the present cost of coal at the mines, and the undisputed record of the operators' yearly state-

ments. But if, in accomplishing this increased production and economy in cost, we have not met the increasing danger of accident to the miner, then the popular idea is a correct one—we have failed in our duty, and the life of the miner has been sacrificed to the benefit of his employer's purse.

I wish to show that this is not the fact, but that, on the contrary, notwithstanding rapidly increasing risk from year to year, we are more than holding our own, that the number of accidents for which the engineer and superintendent are directly responsible is but a small proportion of the total, and that we have a record which compares favorably with that of Great Britain, the representative mining nation of the world.

Whatever improvement the following tables show is made in the face of constantly increasing peril. As the colliery workings broaden and deepen, so do the dangers increase. We contend with additional fire-damp and mine fires, with water and quicksand; a greater weight of roof, and with the additional dangers inside and out that always accompany any increase of machinery.

In early days the miner walked or rode along the level roadway of the drift between his work and daylight, now twice a day there is nothing but a one and one-half inch wire rope between him and eternity, as he is hoisted from the shaft or slope.

Every day increases the outflow of carburetted hydrogen gas, and additional workings daily call for increased ventilating power. The gas, being an unseen danger, is always feared and is carefully watched, but the effort and care of years may be swept away in a moment by the carelessness of an individual. Mine fires are more frequent than formerly. A fire at the Kehley Run Colliery, in Schuylkill County, recently caused the death of two of the best and most experienced superintendents in the region; danger from water and quicksand has been terribly emphasized by the recent disaster at Nanticoke. Falls of roof and coal kill 44 per cent. of those who lose their lives in the mines, and a little thought will show us how the extension of the workings and the exhaustion of the coal is increasing this one great danger.

The breaker machinery, which is becoming more complicated each year, is a source of danger, not lessened by the fact that it is the working place of boys, whose recklessness is proverbial.

A great, in fact the greatest element of danger and the one hardest to meet, is the carelessness of the men. The strictest discipline and most stringent rules seem to have little effect. Some of our anthracite accidents "seem more like suicide than carelessness."

In the last five years thousands of Poles and Hungarians have been brought into the mining region.

The importation of this unskilled foreign labor has added greatly to our death rate, ignorance being joined with carelessness to swell an already overladen death record.

Tables I and II (given below) show the comparative mortality between the six years preceding 1881 and the five years preceding 1886.

TABLE No. I.

Statistics of Fatal Accidents in the Anthracite Mines of Pennsylvania, for the years 1875 *to* 1880.

Years.	Tons mined.	No. of fatal accidents.	Tons mined per one life lost.	Total number of men employed.	Ratio of deaths to men employed.
1875	19,712,472	248	79,486	69,368	280
1876	18,501,011	218	84,867	70,474	323
1877	20,828,179	188	110,788	66,842	356
1878	17,605,262	187	94,146	63,964	342
1879	26,142,689	262	99,781	68,847	263
1880	23,437,242	176	133,166	73,375	417
	126,226,855	1279	98,692	412,870	323

Columns 1, 2 and 3 are taken from Report A C, Pennsylvania Geological Survey, by Dr. H. M. Chance.*

TABLE No. II.

Statistics of Fatal Accidents in the Anthracite Mines of Pennsylvania, for the years 1881 *to* 1885.

Years.	Tons mined.	No. of fatal accidents.	Tons mined per one life lost.	Total number of men employed.	Ratio of deaths to men employed.
1881	30,537,998	273	111,861	76,607	281
1882	31,301,277	292	107,196	82,294	282
1883	33,703,223	323	104,344	91,421	283
1884	32,561,874	332	98,076	101,399	305
1885	34,101,152	312	109,298	100,082	321
	162,205,524	1532	105,879	451,803	294

* Dr. Chance's statistics, as well as mine, have been complied from the reports of the State Mine Inspectors.

COMPARISON OF TABLES I AND II.

YEARS.	Total tons mined.	Number of fatal accidents.	Average tons mined per one life lost.	Total number of men employed.	Average ratio of deaths to men employed.
1875–1880 (6 years)	126,226,855	1279	98,692	412,870	323
1881–1885 (5 years)	162,205,524	1532	105,879	451,803	294
Increase	35,978,669	253	7,187	38,933	
Decrease					29

Roof falls, explosions of fire-damp and careless handling of powder, furnish at least 60 per cent of the deaths. In almost every case these accidents are due to the carelessness of the men. If the superintendent neglects his ventilation, of course gas accumulates; most explosions, however, occur either from direct disobedience of orders, or in cases where the gas accumulating in single breasts is not carefully watched by the miner, and he and his "butty" pay the penalty. When more than two lives are lost by an explosion of gas, the result can generally be attributed (unless direct disobedience be proven) to the superintendent taking too many risks or from criminal neglect of his ventilation. Such accidents are comparatively few, but these few are too many.

The same is true of roof falls; the average fatal fall kills but one man who is too reckless of his own safety; only those accidents where falls cover extended areas can be attributed to the poor judgment of the mine foreman.

The responsibility of accidents from breakage of ropes and machinery rests upon the colliery superintendent. These, and all accidents due to careless inspection, lack of discipline, or a false system of operating, rest upon the engineer and superintendent. And these are the only ones for which they are directly responsible. It is difficult to obtain an exact estimate of accidents for which officials are to blame, but I think 10 per cent. a very high one.

Table No. III shows the record of death in Great Britain for

the past eleven years. It is compiled from the statistics of the "Colliery Guardian."

TABLE No. III.

Statistics of Fatal Accidents in the Mines of Great Britain for the years 1875 *to* 1885.

Years.	Tons mined.	No. of fatal accidents.	Tons mined per one life lost.	Total number of men employed.	Ratio of deaths to men employed.
1875	131,867,105	1244	106,002	535,845	430
1876	133,344,766	933	142,920	514,532	551
1877	134,610,763	1208	111,433	494,391	409
1878	132,607,866	1413	93,848	475,329	336
1879	134,008,228	973	137,727	476,810	490
1880	146,818,622	1318	111,395	484,933	368
1881	154,184,300	954	161,619	495,477	519
1882	156,499,977	1126	138,987	503,987	447
1883	163,737,327	1054	155,349	514,933	488
1884	160,757,779	942	170,656	520,376	552
1885	159,351,361	1150	138,566	520,632	452
	1,607,788,094	12,315	130,555	5,537,245	450

This result of one death to 130,555 tons mined in Great Britain, when compared with one death to 102,608 tons mined in the anthracite district of Pennsylvania, would at first glance seem to prove the greater death-rate on this side of the Atlantic. A little thought, however, dispels this impression.

In the preparation of English coals no breakers are used, coal being directly loaded without elaborate preparation. In the mining of our anthracite coal the breaker wastes one-third of the material hoisted from the mine. For fair comparison, therefore, with the English results we must add 50 per cent. to the shipment to obtain our true production. We must also eliminate from our total all deaths by breaker machinery. I am told that the English miner will use less than ten pounds of powder per month, while our miners use about one hundred and fifty pounds per month, an elimination of $\frac{14}{1}$ of the fatalities from powder explosions will therefore be only just.

COMPARISON OF TABLES I AND II, WITH TABLE NO. III.

	Total tons mined.	Number of fatal accidents.	Average tons mined per one life lost.	Total number of men employed.	Average ratio of deaths to men employed
Great Britain, 1875–1885.	1,607,788,094	12,315	130,555	5,537,245	450
Anthracite region of Penn'a, 1875–1885.	288,432,379	2811	102,608	864,673	308

Anthracite Region of Pennsylvania, Shipment + 50 per cent. = 432,648,568 tons.

Number of Fatal Accidents = 2811 less (221 [Breaker] and 203 [Powder]), 424 = 2387.

432,648,568 tons ÷ 2387 = 181,252 tons (actual) per one life lost.

The mine law of 1870 and the new law of 1885, with the efficient, earnest work of the state mine inspectors, have done much to reduce the death-rate. Day in and day out, the safety of the men is the anxious care and thought of the engineers and superintendents of the region.

They have no cause to regret a record of material progress in the face of increasing difficulties, nothing to fear in comparison with the greatest mining country in the world, and should feel a just pride in the fact that with all their dangers their record leads that of the nation from whom we have learned so much in mining development.

There is still vast room for improvement; if thought and care and constant vigilance can accomplish such improvement, it will be made, and we may look forward to a future progress greater than that of the past.

VIII.

EFFICIENCY OF LOCOMOTIVES AND RESISTANCE OF TRAINS.

By George R. Henderson, Active Member of the Club.

Read November 6th, 1886.

The efficiency of locomotives can be divided into two principal parts: the first depending upon the size of the cylinders and wheels, the valve gear, boiler and steam passages, of which the *tractive power* is a function, and the second upon the speed, grade, curvature and friction, which combine to produce the *resistance.*

The *tractive power* may be determined as follows:

Let P = tractive power.
p = average effective pressure in cylinder.
s = stroke of piston.
d = diameter of cylinders.
D = diameter of driving wheels.

then

$$P = \frac{4\,\pi\,d^2\,p\,s}{4\,\pi\,D} = \frac{d^2\,p\,s}{D}.$$

The average effective pressure can be obtained from an indicator diagram, or by calculation, when the initial pressure and ratio of expansion are known, together with the other properties of the valve motion. The subjoined table from "Auchincloss" gives the proportion of mean effective pressure to boiler pressure for various proportions of cut-off. (Pressures above atmosphere.)

Cut-off at — of Stoke.	M. E. P. (Boiler Pres. = 1)	Cut-off at — of Stroke.	M. E. P. (Boiler Pres. = 1)
.1	.15	.45	.62
.125 = $\frac{1}{8}$	.2	.5 = $\frac{1}{2}$	.67
.15	.24	.55	.72
.175	.28	.625 = $\frac{5}{8}$	.79
.2	.32	.666 = $\frac{2}{3}$	.82
.25 = $\frac{1}{4}$	.4	.7	.85
.3	.46	.75 = $\frac{3}{4}$	.89
.333 = $\frac{1}{3}$	.5 = $\frac{1}{2}$	.8	.93
.375 = $\frac{3}{8}$	.55	.875 = $\frac{7}{8}$	.98
.4	.57		

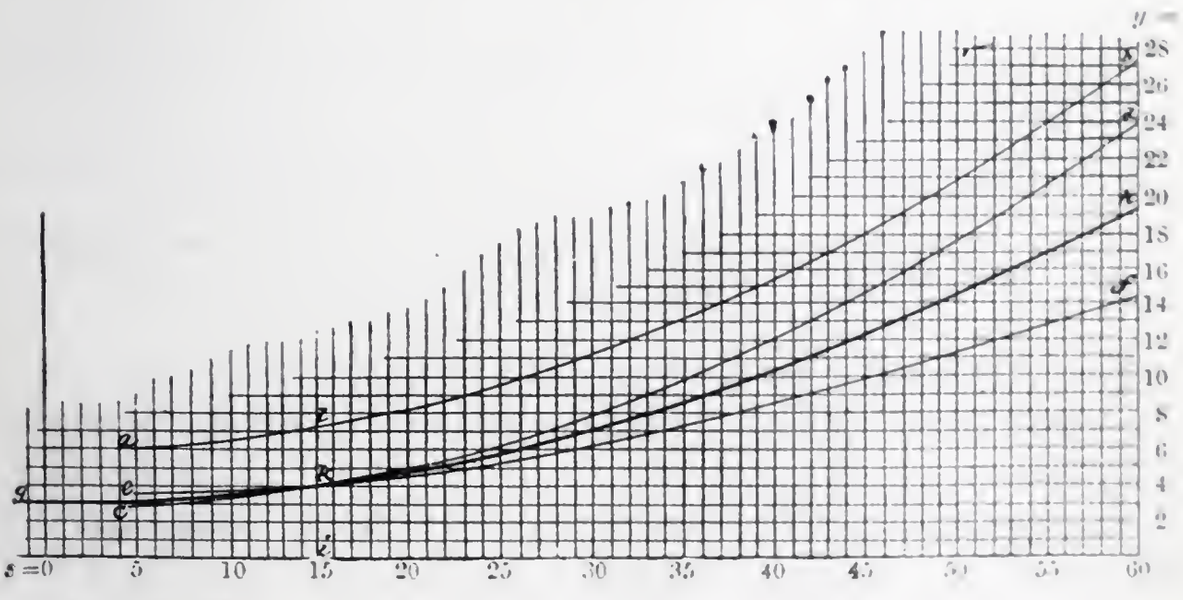
These values were deduced from experiments with an English locomotive by Mr. Gooch. As diagrams vary so much from different causes, this table will only fairly represent practical cases. It is evident that the cut-off must be such that the boiler will be capable of supplying sufficient steam at the given speed.

(In the following calculations it is assumed that the adhesion of the engine is at least equal to the tractive power, which is generally the case—if the engine be well designed—except when starting, or running at a very low rate of speed, with a small expansive ratio. When running faster, economy, and also the size of the boiler, necessitate a higher ratio of expansion, this reducing the tractive power below the adhesion. *If the adhesion be less than the tractive power, substitute it for the latter, in the following formulæ.*)

The *resistances* can be computed in the following manner, first considering the train.

There is a resistance due to friction of the journals, pressure of wind, etc., which increases with the speed. Most of the experiments made with a view of determining the resistance of trains have been with European rolling-stock and on European railways. The few trials that have been made here seem to prove that with American systems this resistance is less. In determining the proper (?) values I proceeded as follows:

a—b is the curve of values deduced from foreign experiments, the abscissæ representing speeds in miles per hour, and the ordinates resistances in pounds per ton of weight of train. Our



own experiments (those on the P. R. R.) were made principally at a speed of 15 miles an hour, and gave a resistance *i—k*. If we assume our resistances to be proportional to *a—b* as *i—k* is to *i—l*, we get the curve *e—f*. But in order to be on the safe side, and to allow for not having direct experiments at various speeds, the curve *c—d* was drawn, which is less than *a—b* by the constant quantity *k—l*, and a new curve *g—h* constructed, which is the mean of *c—d* and *e—f*. This curve is a parabola whose parameter is 217, and whose apex is distant from the origin by 3, its axis coinciding with the zero ordinate of speed. Its equation is

$$y = \frac{s^2}{217} + 3$$

where s = speed in miles per hour.

y = resistance in pounds per ton of load.

If we wish the value of l = coefficient of resistance in terms of the load, we get

$$l = .0015 \left(1 + \frac{s^2}{650}\right).$$

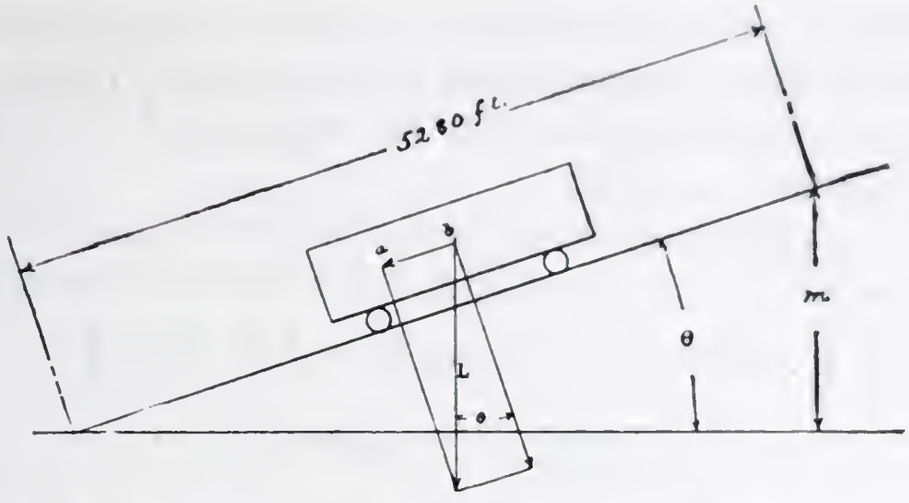
As the curve is a parabola whose axis passes through the origin, in fact coincides with the axis of "y," there must be a similar branch on the *minus* side of the origin. But a minus speed must be understood as referring to a backward motion, and evidently the resistance would be the same as for running forward.

The following table gives the values of y and l for different values of s:

s =	5	10	15	20	25	30	35	40	45	50	55	60
y =	3.1	3.4	4.	4.8	5.8	7.1	8.6	10.2	12.1	14.3	16.8	19.2
l =	.0015	.0017	.0020	.0024	.0029	.0035	.0043	.0051	.0060	.0071	.0084	.0096

The resistance due to curvature is about .5 lbs. per ton per degree of curvature, or for the coefficient = .00025 c, where c = the curvature in degrees.

The effect of grades may be determined by referring to the theory of the "inclined plane."



Consider a load "L" on a grade of "m" feet per mile, as in the figure. The component of the weight L acting in the line of traction, or parallel to the track, is

$$\overline{a\ b} \text{ or } L \sin \theta,$$

$$\text{but } \sin \theta = \frac{m}{5280}$$

$$\therefore \overline{a\ b} = \frac{L\ m}{5280} = .00019\ L\ m.$$

We are now ready to combine these coefficients in one equation representing the resistance of the train.

Let L = weight of train, exclusive of engine.
R = resistance of train.
s, c, and m, as above.

then

$$R = L \left[.0015 \left(1 + \frac{s^2}{650} \right) + .00025\ c \pm .00019\ m \right]$$

the $\pm$ sign meaning that this coefficient is positive for ascending and negative for descending grades.

To find a grade upon which a train would descend by itself, it is only necessary to take the last coefficient minus and make $R = O$, hence

$$L \left[.0015 \left(1 + \frac{s^2}{650} \right) + .00025\ c - .00019\ m \right] = O, \text{ or}$$

$$m = 7.9 \left(1 + \frac{s^2}{650} \right) + 1.3\ c.$$

The resistance of the engine and tender may be taken for grades as above. As locomotives usually have a long rigid wheel-base, the coefficient for curvature had better be doubled.

The resistance due to the friction of the working parts will be considered as being proportional to the tractive power, so that the effective tractive power will be represented by "$u\ P$," the resistance being $(1 - u)\ P$.

Combining all these values, there results the equation between the tractive power and the weight of the train and engine:

$$u\ P - W\left(.0005\ c \pm .00019\ m\right) = L\left[.0015\left(1 + \frac{s^2}{650}\right) + .00025\ c \pm .00019\ m\right]$$

"W" being the weight of the engine and tender, and "u" being probably about .8

Transforming we have

$$L = \frac{u\ P - W\ (.0005\ c \pm .00019\ m)}{.0015\left(1 + \frac{s^2}{650}\right) + .00025\ c \pm .00019\ m}$$

and

$$P = \frac{L\left[.0015\left(1 + \frac{s^2}{650}\right) + .00025\ c \pm .00019\ m\right]}{u} + \frac{W\ (.0005\ c \pm .00019\ m)}{u}.$$

In using these formulæ, the value of $.0015\left(1 + \frac{s^2}{650}\right) = l$ may be taken out of the second table, thereby simplifying the equation.

I would merely add that these deductions agree well with railroad practice.

IX.

THE ST. PAUL ICE PALACE, 1885 AND 1886.

By Herman Haupt, Jr., Active Member of the Club.

Read November 6th, 1886.

We who live in this far northern region are looked upon by the world at large, and the people of the South in particular, as beings doomed by King Frost to spend a long and dreary winter

buried beneath the ice and snow of an almost Arctic winter, and dwelling in a climate where the human species dare not venture out except wrapped in furs, and where business and the ordinary vocations of life are for the most part suspended till the genial summer sun has returned from the South and made glad the face of Nature.

This surmise is very erroneous, and the fact is that a more agreeable winter climate does not exist. Cold it is unquestionably, but the air is dry and clear, and a highly electrical condition exists at all times, which exhilarates and warms the whole system into a glow that is delightful.

The Ice Palace, which is the subject of this paper, had its origin in the suggestion of Mr. George Thompson, of St. Paul, and was reared in about forty-two (42) days, in Central Park, in the City of St. Paul, the grounds covering an area of about eight (8) acres.

The entire structure was of ice, laid block upon block, making a building one hundred and eighty (180) feet long and one hundred and fifty-four (154) feet in width, with a tower rising to the height of one hundred and six (106) feet.

When the huge pile of glittering ice was seen in the rays of a bright sun, and the mercury at zero, or at night, illuminated by the numerous electric lights, the sight was surpassing in brilliancy and impossible of description.

The ground plans of the structure were rectangular in form, having a main front and a rear entrance. The front entrance consisted of a Gothic arch of about ten (10) feet in width and twenty-five (25) feet in height, cut into the face of a round tower fifty (50) feet high. On either side of this tower were square towers each eleven (11) feet square and rising about ten (10) feet above the round tower. Flanking the two square towers and running at right angles with the same, were walls of ice rising to the height of thirty-three (33) feet, terminated at the outer ends by round towers fifty-six (56) feet in height, capped by a cone terminating in a crown of blocks.

Extending from these towers backward at right angles with the walls was a second wall of equal height with the first, abutting against the east and west wing of the main castle wall. This structure being repeated at the four (4) corners, a court-yard was

formed, which communicated with the main structure by arched passages through the walls of the castle proper.

The main structure was in general cruciform, consisting of a square Norman tower, flanked by four smaller towers and an east and west wing, running outward to the enclosing wall and extending beyond it.

The wings were each supported by two smaller square towers, one (1) on the north and another on the south sides of the wing.

The towers supporting the main tower, four (4) in number, were of a square shape, the towers on the north and south sides being higher than the east and west towers by about twenty-six (26) feet.

The main tower was supported at the four corners by cylindrical towers rising from the foundations with a uniform diameter, and crowned by a cap and enlarged crown piece. The southeasterly tower carried a staff at its summit, with the ensign of King Borealis, a white bear rampant upon an azure field.

All the walls and square towers were crowned or finished with blocks of ice set on end leaving space between them.

The Construction.

The broad surface of the Mississippi River was freed of snow by means of a long scraper drawn by two horses, and formed of a tongue of wood having planks ten (10) feet long secured to it, at right angles, and pitched at an angle to carry the snow up in a ridge before it, the plough or scraper being furnished with handles to guide it.

The snow being removed a plough called a marker was run over the surface of the ice to mark the ice into blocks. The first plough had blades for marking, set twenty-two (22) inches apart; this plough was run in one direction, and a second plough, in which the blades were forty-four (44) inches apart, was run in a direction at right angles with the first set of lines, thus marking the ice into blocks twenty-two (22 in.) by forty-four (44 in.) and of a thickness *pro re nata.*

When so marked the blocks were sawn out by means of long saws, worked upward and downward by a man who walked backward following the marks of the plough.

The blocks were then hauled to the palace, and for round or cylindrical structures roughly shaped with an axe, but untouched for the walls and square towers.

In building the walls a derrick was used, consisting of a shaft with a cross-piece secured at right angles at its summit with a pulley at each end. At the base of the shaft was a third pulley, and a Jacob's ladder extended from the bottom to the top of the shaft to enable the workmen to ascend and descend to the top of the walls. A rope passed over these pulleys and at one (1) end was attached a pair of ice-tongs, at the other a team of horses supplied power; with this device the blocks of ice, 22 in. x 44 in. x 20 in. (the last dimension being the thickness of the ice on the river last winter), were hoisted into place, and when set were cemented by having water poured into the cracks, which froze almost immediately.

The blocks for the square towers and walls were left in their primitive shape, but the blocks for the round towers, after being roughly dressed to a given shape upon the ground, were hoisted into place, cemented with water, and then dressed off to shape with an axe.

The arches were formed by building upon temporary wooden frame-work, which was removed so soon as the cementing water was congealed. The windows were formed by long spaces between the blocks.

Thus block upon block, and row upon row, with a mortar as thin as water, was reared the first Ice Palace in the United States of America, of which I hand you a set of photographs.

X.

WATER PIPES.

By A. H. Howland, Active Member of the Club.

Read December 4th, 1886.

In preparing an article on any subject of general interest it is usual to devote more or less time to incorporating Ancient History in the same. In this busy, go-ahead age of ours, it hardly

seems necessary to go back very far in the history of any subject to ascertain that which is best and most suitable for our present wants. This age is remarkably one of the present and future, rather than one of the past, and I will not therefore take up your time in rehearsing the many kinds of water pipes used by the ancients, their methods of manufacture or the relative values of the various kinds, but will proceed directly to a consideration of those in use to-day, and see, as far as lies within my power, how nearly each fills the requirements, wherein it fails, or wherein it might be improved. At the present time the largest amount of pipes in use are made of cast iron. I presume that there are one hundred times as many miles of cast iron pipes in the ground as there are of all other kinds. The other kinds that have received any considerable attention and use are, in the order of their proportionate use, a riveted wrought iron shell, lined and coated with cement mortar; lap welded or riveted wrought iron pipes, coated with asphaltum or protected with various forms of metallic coating or oxidization of the surfaces; wooden pipes; earthen-ware pipes, and composition pipes. Cast iron pipes have come to be accepted as a so-called standard, on account of the plentifulness of the material of which they are made, its ease of manipulation and comparative cheap cost.

Iron may be called the back-bone of this country; it enters into the composition of nearly everything we use, in some part or other; but I think there is hardly any department of the arts or sciences in which less advancement, less exact knowledge, has been displayed than in the manufacture of cast iron water pipes. The manufacturers have gone ahead and turned out immense products that are reliable only in their bulk, and consumers have taken and used them without inquiry or much knowledge as to their nature or adaptability.

In designing or constructing a bridge, the engineer of the present day first determines the amount and nature of the load which the bridge is intended to carry, or will be called upon to carry; he then designs his bridge, first, as to the best form for the place, and second, as to the distribution of the strain and the material to resist the same, keeping in eye at all times the probable load. After securing his material he determines what

factor of safety it will be safe to use in each of the various members of his structure, and then knowing the ultimate strength of the material he is using, he readily determines upon the various forms and proportions of the structure.

In cast iron water pipes exactly the opposite of this course is pursued. Some engineers of my acquaintance are using 6-inch water pipes that weigh 42 pounds to the lineal foot, and tell me that they know of no reason why they should, except that their predecessors in office have established that weight and they have adhered to it. Forty-two pounds per lineal foot of water pipe represents an average cost, in the eastern part of the country, of 63 cents. If pipe weighing but 30 pounds to the lineal foot would be sufficient for the uses to which it is put, that pipe would cost but 45 cents per foot, or, in other words, the heavier weight of pipe costs nearly 50 per cent. more than pipe that would answer all the requirements. This unnecessary percentage, if it should be found in all of the works of this country, would represent an enormous sum, which is, in one sense, worse than wasted, and which engineers should use their technical and practical knowledge to endeavor to save. In determining what weight of cast iron water pipe should be used, the same factors must be considered that are considered in determining the dimensions of a bridge or other structure. What is the probable maximum load, what is the form and what is the quality of the material available?

The first question can only be determined by the circumstances connected with each particular place. For instance, there are some works in the country where the maximum static pressure is 25 or 30 pounds to the square inch, in others it is 200 pounds to the square inch. Of course, pipe that would be suitable for the lower pressure might not answer for the greater. While the greater static pressure, however, might not be in excess of the strength of pipe of the minimum thickness which the present state of the art renders possible to make, still the extraordinary pressure to which the pipe is liable to be subjected is more where the static pressure is 200 pounds than where it is but 20 or 25.

In manufacturing the pipe it has been found impracticable to make pipes of given diameters of less than certain thicknesses, or if it were possible to make them of less thicknesses, the great

danger of breakage in handling or transportation comes in to prevent extreme thinness, and I think I am within the bounds of reason when I state that the minimum thickness of any pipe under 24 inches in diameter gives sufficient material so that the pipe when made will withstand 300 or more pounds pressure to the square inch. This being the case, and there are few if any works having 300 pounds pressure to the square inch, the question naturally arises, why do we not take the minimum for all places. This brings us to the consideration of the extraordinary pressure to which pipes may be subjected. The first, and that which is most common, is an external pressure, caused by the unequal bearing of the pipes in the trench, and the heavy load placed upon its upper surface, especially in the streets of a city where there is heavy traffic. I have known a pipe in the city of Boston to be broken in three or four places by this reason alone, and as the pipe was of considerable weight and strength, it would not seem that any thickness of pipe we would probably use could have withstood the pressure to which this pipe had been subjected. From observation of this and many other cases I have concluded that we cannot safely provide in thickness of material against any of these cases of external pressure, and that we should look for safety in this particular to our men who lay the pipes, and be sure that they obtain full and sufficient beds for the pipe in all cases. We do not, therefore, need to add to the minimum thickness anything for this. The external pressure caused by direct crushing pressure of the superincumbent earth, or other material, is never, except in extraordinary cases, more than one-fifth the resisting strength of the material of which the cylinder is composed, when the same is properly supported. We do not need, therefore, to add anything to the minimum thickness for this. The next and most important of these extraordinary pressures is that caused by water hammer; and when we begin to talk of water hammer we enter upon a subject of which very little is known. It is perfectly easy to calculate the momentum of a column of water of a given size flowing with a given velocity, and the pressure caused by instantly stopping that water, but it is not so easy to calculate, nor do I know that it has ever been calculated, what the amount of this pressure would be when this

water is stopped gradually. We all know from experience that it is impossible to stop a 12-inch column of water so gradually as to produce little or no water hammer on our pipes. We all know, probably, of some instance in which a much smaller column of water, say two to four inches, has been so suddenly stopped as to burst many lengths of pipe, sometimes at great distances from the point of stoppage. As it is impracticable to build any system of works of any material having sufficient strength to resist the greatest water hammer that we can conceive might be caused, the question comes up as to how much we should provide for, whether we can expect all our employees and all users to be so intelligent and so careful in opening and closing gates, hydrants, valves, etc., that there shall be no shock or water hammer, or whether we have got to provide for a certain amount of ignorance and carelessness on their part, and if so, how much, and it is a very important question.

I have seen recording gauges indicate a pressure of 50 per cent. more than the normal, by the opening and closing of a hydrant on the pipe line more than a mile away from the gauges; other times I have seen a hydrant, within a few feet of the gauge, in which the water hammer caused by the closing of the same was hardly perceptible. One case represents careless use and the other intelligent and careful use.

In the various works with which I am connected I have complete sets of recording gauges, and have carefully watched and tested them for long periods, but I must confess that I have not yet come to any conclusion which I can consider absolutely warranted by the facts.

If we should take works where the static pressure is 100 pounds and allow that pressure to be doubled, or 200 pounds, I think that we should be allowing sufficient, and if anybody connected with the works, or using water from the works, should be so careless or ignorant as to cause a water hammer of more than 100 per cent. of the normal pressure, it would then be the part of wisdom and economy to put into the works such fixtures only as would guard against disaster by a repetition of the act.

Still, there might be cases where, even with the utmost care and watchfulness, a water hammer much in excess of 100 per

cent. of the normal pressure might be caused, and the question will have to be settled by each, in his own case, whether to so build their works that the most ignorant and careless use of them will cause no injury, or whether they will inaugurate a system sufficient for all reasonable uses and provide apparatus, and insist on their use in such manner as not to injure the works, and thus save annual expenses in the shape of interest upon dead plant by the use of intelligent common sense.

In relation to the strength of pipes, it is a simple matter to calculate the resistance of a perfect cylinder, made of a certain quality of material, against an internal pressure; but until you are willing to pay a fair price and insist upon good material and good workmanship, we must pay for an excess of material sufficient to insure us against the poor quality of the material and the carelessness of the workman. Just what percentage to add to the minimum thickness of pipe for all these things is a little uncertain; but from a careful examination and study of all the data obtainable from 500 different works in the United States and Canada, I have concluded that for all we have to guard against, either in quality of material, carelessness in manufacture, carelessness in handling or laying, or against water hammer, a factor of safety of five is ample, and this only on the larger pipes.

At the present time it is perfectly feasible to obtain pipes made of material having a tensile strength of 18,000 pounds to the square inch, and with such material the minimum thicknesses of various sizes of pipe, together with their weights and ultimate strengths, are as follows:

Internal Diam.	Minimum Thickness.	Weight per foot of cylinder.	Weight per foot of pipe, laid, including bells.	Weight per length to lay 12 feet, including bells.	Ultimate strength if made of 18,000 lb. iron.	One-fifth of the ultimate strength
4	0.32	13.57	14.67	176	2880	576
6	0.35	21.82	23.83	286	2100	420
8	0.37	30.43	33.00	396	1665	333
10	0.40	40.83	44.33	532	1440	288
12	0.45	55.00	59.83	718	1350	270
14	0.47	66.76	72.75	875	1210	242
16	0.50	80.99	88.42	1061	1125	225
18	0.52	94.54	102.25	1227	1040	208
20	0.55	110.95	117.92	1435	990	198
24	0.60	114.89	156.50	1875	900	180
30	0.70	210.97	227.00	2724	840	168
36	0.80	289.04	310.75	3729	800.	160
40	0.85	340.87	369.25	4431	765	153
42	0.90	379.03	410.58	4927	770	154
48	1.00	481.02	521.08	6253	750	150

From this it will be seen that a six-inch pipe of the minimum thickness of .35 of an inch, weighing 21.82 pounds to the foot of cylinder, made of material having a tensile strength of 18,000 pounds to the square inch, has a theoretical ultimate strength of 2,100 pounds to the square inch, and with a factor of safety of five, it would be safe to use this pipe against a pressure of 420 pounds to the square inch. This may seem a little doubtful to you, but I ask you, in all frankness, why you would use heavier, and I do not think there is one here but who would say that this pipe, light as it is, is sufficient for the uses of all water works, except that it is lighter than is usually used. In this connection I would say that I know of seven different works in the country where the maximum pressure is 200 pounds to the square inch, and one of these works uses six-inch pipes with perfect safety, weighing but 28 pounds to the lineal foot, while another, under almost exactly similar circumstances, uses pipe weighing 48 pounds. If the lesser weight is sufficient, and experience has proved it so, then the heavier weight is a waste and one that no department can afford, or no engineer be warranted in putting in at somebody's else expense.

I think possibly some of you may have in mind that the six-inch pipe, .35 of an inch thick, is too thin to tap successfully. I think in this again you are wrong, as with the present forms of tapping machines and the use of corporation cocks having a short plug tap, with nut and washer, it is perfectly feasible to make a service connection on a six-inch pipe even .3 of an inch in thickness.

By examination of the tables it will be seen that while the minimum thickness increases from .32 of an inch for four-inch pipe to .5 of an inch for 16-inch pipe, the ultimate strength decreases from 2,880 pounds to 1,125 pounds for the 16-inch pipe, and for the 24-inch pipe the minimum thickness has increased to .6, and the ultimate strength decreases to 900 pounds.

There are very few works that use 24-inch pipes under a pressure of one-fifth of 900 pounds, or 180, and very few, if any, that use pipes, under any pressure, as light as this.

In the reports from 38 different places using 24-inch pipes under various pressures, I find one place using pipe weighing as light as 182 pounds to the foot, which would be about .7 of an inch in thickness; while another works, under the same pressure and probable circumstances, uses pipes weighing 306 pounds to the foot, or about 66 per cent. in excess of the lighter. I do not know that I have strength of conviction enough to advocate the use of 24-inch pipe only .6 of an inch in thickness for any works where there is any pressure at all, although my estimates and figures show that it would be perfectly safe, but it is so radically different from custom that I have, to a certain extent, given way to custom and prejudice, and have adopted as standard weights for all pipes used in the works contracted for by myself, as follows:

Internal Diam.	Thickness, inches.	Weight per foot of of cylinder.	Weight per foot of pipe, laid, including bells.	Weight per length of pipe to lay 12 feet.	Ultimate strength when made of iron having tensile strength of 15,000 lb.	One-fifth of the ultimate strength.
4	0.40	17.27	18.75	225	3600	720
6	0.42	26.46	28.92	347	2515	503
8	0.45	37.33	40.50	486	2025	405
10	0.50	51.54	56.17	673	1800	360
12	0.55	67.76	73.75	885	1650	330
14	0.58	83.02	90.67	1088	1490	298
16	0.60	97.78	106.78	1281	1350	270
18	0.64	117.11	126.67	1520	1280	256
20	0.70	142.25	153.43	1841	1260	252
24	0.80	194.77	210.33	2524	1200	240
30	0.90	273.00	285.33	3524	1080	216
36	1.00	363.22	390.50	4686	1000	200
40	1.10	443.82	480.83	5770	990	198
42	1.16	491.49	532.42	6389	995	199
48	1.30	629.16	681.58	8179	975	195

I think in this I allow a large excess over and above that which is necessary, and shall probably reduce my weights somewhat in the near future.

When the pipe manufacturer tells you that a certain weight of pipe, much in excess of what you know has been used successfully, is necessary, you of course understand that he is advocating the heavy weight entirely from a selfish standpoint, as it is much more to his advantage to sell you pig iron at pipe price than otherwise. But when you use cast iron water pipes, I ask you to consider it in the same light and with the same method as you do any other material, make your specifications so as to insure as near as possible the perfection of manufacture, and insist on the manufacturers living up to the same.

As a protection against corrosion, on both external and internal surfaces of the pipes, the usual habit has been to treat them in the manner originated and first used by Dr. Smith, of England, which was to immerse in a hot bath of deodorized coal tar and linseed oil. The Dr. Smith method has been improved upon by a good many makers, by adding a small percentage of asphal-

tum and by heating the pipes as well as the mixture, and when the pipes, thoroughly cleaned, are dipped in such a mixture, the result is a smooth, hard, glossy coating, which it is difficult to remove, and which is not acted upon by the usual waters confined in the pipes or found in the soils in which the pipes are buried. To properly coat pipes in this method requires time and care, and costs money, and I am sorry to say that a good many manufacturers do not coat pipes as they should be coated or as they claim to coat them. A poorly coated pipe is not much better than a naked one, and it is therefore of the utmost importance that you insist upon the makers living up to your specifications, which should call for the best material, applied in the best manner.

Cement Lined Pipes.

In certain sections of the country so-called cement lined pipes have been used to quite a large extent, and I think next to cast iron pipes they have the largest mileage to their record of any pipes made. They have their friends and their enemies, and a good deal can be said on both sides of the question for and against them. At the time their use was most general in the Eastern States, their cheapness was their principal attraction, and a good many municipalities brought themselves to believe that they were worthy of their confidence, because it was for the interest of their pocket-book to so believe, but that they have proved "a delusion and a snare" is well known.

Three years ago I sent personal letters to every department whose address I could obtain throughout the United States and Canada that had ever used wrought iron cement lined pipe, and received a very large number of replies. From a careful study of these replies I find that the average life of the cement pipe, as usually made, was eight years, and that no place, with two exceptions only, who had had these pipes in use for a longer period than eight years, recommended them.

Cement, in itself, is free from all objection as a material through which to convey potable waters, but to utilize it in a permanent and economical manner is a difficult question.

The earlier forms of the cement lined wrought iron pipes were

composed first of thin shells of sheet iron with their edges lapped and riveted, and sometimes additionally strengthened by means of longitudinal strips on both outer and inner sides of the lap. These shells were supposed to be water tight in themselves, and to have sufficient strength to resist the maximum pressure of water to be confined in them. After riveting, these shells were lined with a thin coating of cement mortar, usually composed of one-half sand and one-half American hydraulic cement. After lining and before this cement had hardened, the shells were laid on their sides so that the light could enter, and any imperfections in the lining that could be seen from one end were removed by the use of proper tools and the ends trimmed and completed ready for the joint. After the cement had properly and thoroughly set, these shells were conveyed to the trench, laid in a bed of mortar, joined to their neighbors by a wrought iron band, and the whole exterior surface of the pipes covered with a coating of mortar. Usually the joint was filled and covered with neat cement rather than cement mortar. As soon as the cement on the outer side had sufficiently set, so as to retain its position and form, the pipes were covered and the trenches refilled in the usual manner.

The objection to this class of pipe is, first, cement mortar, composed of one-half sand and one-half cement, is not an impervious material, and water, under ordinary pressure, is forced, to a greater or less extent, through it and so comes in contact with the shell, which it eats until it has no strength left, when the pipe is destroyed. In examining many miles of this pipe which has been taken out and replaced with cast iron, I have noticed that wherever a joint was made and covered with neat cement, the iron has been in almost as good condition as the day the pipe was laid, and this gives rise to the belief that a wrought iron shell, lined and coated with neat cement, would have greater durability and life than one lined and coated with cement mortar. Whether such a pipe can be perfectly made or not is a serious question, and is the only question which prevents a much larger and more general use of this kind of pipe. The many manipulations necessary before the pipe is complete in the trench, and the fact that both the lining and coating depends for its

efficiency upon the manipulation of mechanics, allows too many possible mistakes or errors to creep in and so render the pipe imperfect. This pipe is readily and cheaply made and has many adherents at the present time.

Wrought Iron Coated Pipes.

In many places in the western part of the country, wrought iron, riveted pipe simply covered with asphaltum have been used for many years and with the best results, principally in works connected with hydraulic mining and irrigation, but in some few cases they have formed the main supply pipes for a city or town. They have given good results as far as strength and durability are concerned, the only objection to them being their cost and the increased loss of head by friction on the lapped and riveted seams.

Within the last few years lap welded wrought iron pipes have begun to be used and they have proved so far to be worthy of confidence; they are light, easily handled and fitted, exceptionally strong, are not injured by rough usage, settlement of the ground, or water hammer; present smooth interiors, and on this account, and the fact that they usually come in lengths of eighteen to twenty feet, have a greater carrying capacity, on account of reduced friction, than cast iron pipes of the same diameter.

Several different methods of joining these pipes have been devised, but that which seems to be the simplest and best and to meet all the requirements, is a simple cast iron sleeve, locked on to rivets in the ends of the pipe, a joint between the two being made with hot lead poured and caulked in the same method as on cast iron pipes.

The only question, or objection, that can be raised against these pipes is that of durability. The asphaltum coating used on the Pacific Slope is undoubtedly good as long as it remains perfect, but in the handling necessitated by transportation and laying, this is apt to become abraded and the naked iron exposed, although in some twenty miles of this kind of pipe that I laid three years ago, I have heard of no place where the asphaltum has been removed and corrosion commenced.

Several chemical processes to protect the iron have been tried, principally among which may be mentioned the Kalemein process, the Bower Barff process, and the Wallen process.

The first of these has been extensively used in this country and has given, as far as I can learn, good results when thoroughly done, but in common with all processes that are used by ignorant workmen on a large scale, it is liable to be imperfect in results, and in some forty miles of this pipe which I have laid, I have had it doubly treated with the Kalemein mixture and afterwards coated with asphaltum.

A line of 12-inch pipe, thus treated and laid in 1883, was recently taken up and lowered to correspond with the change of grade of the street, and careful examination showed that the pipe was as bright and clean inside as when first laid, and I have not heard of any places being found, where it has been dug up for the purpose of making connections, etc., that were not in good condition.

The Bower Barff process is a combination process by which the surface of the iron is oxidized and thus further corrosion is prevented. I do not know of much of this pipe having been used, but some samples which I have that were treated in England have not shown a very high state of preservation, numerous rust spots coming upon them, although only exposed to the atmosphere.

The Wallen process is a process of coating with copper, similar to electro-plating, but it has the advantage over plating, in that by it the copper seems to become a part of the surface of the iron and is not liable to be peeled or flaked off by rough usage or blows. This process has but just been introduced into this country and has not had the test of time, but a large number of samples which I have had have so far proved good, and I have great hopes that the process can be put upon a successful commercial basis, so that large pipes can be treated and it be given a thorough test.

It is my opinion that wrought iron pipes treated in some one of the methods indicated, or in some method yet to be discovered, will soon supersede, in most cases, all other kinds of pipe.

Wooden Pipes.

Wooden pipes are used to a limited extent in the northern central portion of the country, and are, I believe, the only pipes in which the diameter increases with use. They have many advantages and a considerable number of disadvantages. Their bulkiness, short lengths, the difficulty encountered in joining them together and maintaining a joint under all conditions, renders them a questionable article. When made of good, soft pine they are unobjectionable, from a sanitary point of view, as water conveyors. In some soils they have proved very durable, while in others they have lasted but a few years.

In order to strengthen this pipe, and make it possible to use a larger diameter of bore in a given size of log, they are sometimes wound spirally with wire or small hoop iron and afterward dipped in hot tar and sanded.

Earthen-Ware Pipes.

Earthen-ware pipes, or what is commonly known as vitrified pipe, is used in some places for conduit pipes, and in a few cases, that have come to my knowledge, for distribution pipes. I have known them to be used in works where the static head is 40 pounds and they have given good results for years. In these cases the joints have been made with a band of wrought iron filled with brimstone. The pipes have been tapped with a band, filled with brimstone, and then a hole drilled through the corporation, the brimstone and the pipe. They make a clean, durable conductor, reasonable in cost, but have the objectionable features of reduced capacity, on account of friction caused by the frequent number of joints, and the irregularity of their shape.

Composition Pipes.

Composition pipes made of various substances, but principally of asphaltum and canvas, have been used to a limited extent but found entirely inadequate as to capacity, durability and convenience of handling.

Glass Pipes.

Glass pipes, of large diameter, have not been successfully pro-

duced, but it has been predicted by several large glass manufacturers that it will not be long before some method of casting these pipes, successfully and cheaply, will be devised.

Made in form similar to our present cast iron pipes, with some suitable device for a joint, and of a malleable glass, they would form a water pipe to which there could be scarcely an objection; strong, tough, smooth and indestructible, and made of a material that is found almost everywhere; it is not without the range of probability, that whenever a large quantity of pipe is to be used in any one locality, a furnace will be erected and the pipes made where they are to be used.

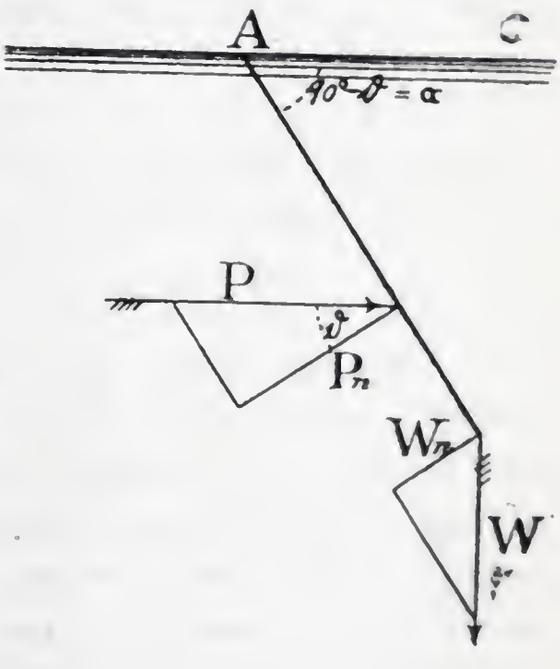
XI.

EQUILIBRIUM AND STABILITY OF THE FLOATING CURRENT DEFLECTORS DESIGNED FOR HARBOR AND RIVER IMPROVEMENTS.

(Supplement to "Harbor Studies.")

By Prof. L. M. Haupt, Active Member of the Club.

Read December 18th, 1886.



Let $A\ W$ = section of the vertical deflector or shield.

P = resultant pressure of current.

$P_n = P \cos \vartheta$ = normal pressure of current.

W = load or counterpoise.

$W_n = W \sin \vartheta$ = normal load.

l = leverage of P_n about A as center of rotation.

l' = leverage of W_n about A as center of rotation.

then the equation of equilibrium will be

$$l\,P \cos \vartheta - l'\,W \sin \vartheta = O$$

$$W = \frac{l}{l'} P \cot \vartheta \qquad (1)$$

if W be at end of shield then $\frac{l}{l'} = \frac{2}{3}$ and (1) becomes

$$W = \tfrac{2}{3}\, P \cot \vartheta \quad (2)$$

When $\vartheta = O$, $\cot \vartheta = \infty$ as it should be, for then the shield is vertical, and the pressure and weight are not opposed, but at right angles to one another.

When $\vartheta = 90°$, $\cot \vartheta = O$, for then the pressure P is parallel to the shield, and theoretically does not act upon it (assuming the shield to have no weight).

To find W in terms of P_n, the normal pressure due to the velocity of the current:—substitute its value in (2) and there will result

$$W = \tfrac{2}{3}\, P_n \sec \vartheta \cot \vartheta \quad (3)$$

If the shield be 21 ft. long then $A\,W = l' = 21$ ft.

If the velocity at the gorge be $v = 5$ ft. per sec., which is sufficient to move 2″ square stones, then P_n will be 25 lbs. per square foot, and the pressure on one section of a shield a foot wide must be $25 \times 21 = 525$ lbs. $= P_n$.

If ϑ be 30° the deflector will make an angle with the surface of $(90 - \vartheta) = 60°$, and from (3) the value of W must be $= \frac{2}{3}\, P_n \times 2 = \frac{4\,P_n}{3}$.

When $\vartheta = 60°$, $W = .77\ P_n = 404$ lbs. per lineal foot. W will $= P_n$ when $\frac{2}{3} \sec \vartheta \cot \vartheta = 1$, that is, when $\frac{2}{3} \sec \vartheta = \tan \vartheta$ or $\frac{2}{3} \frac{1}{\cos \vartheta} = \frac{\sin \vartheta}{\cos \vartheta}$ from which $\sin \vartheta = \frac{2}{3} = 0.666$ and $\vartheta = 41°$ 48′. Therefore when the counterpoise is equal to the normal pressure a, the angle which the shield makes with the surface will be 48° 12′, or a shield would cover 75 per cent. of the depth, if long enough to reach bottom when vertical. Thus the *mean* velocity would be increased four-fold, but the bottom velocity would be increased in a much more rapid ratio because of the vertical component depressing the axis of the current.

TABLE OF VALUES

for $Pn = W$, for $a = 48° 12'$ and $l' = 21$.

ft. per sec.	$P_n = W$ for l' 21.
$v = 1$	21 lbs.
$v = 2$	84 "
$v = 3$	189 "
$v = 4$	336 "
$v = 5$	525 "

NOTE.—If W is of iron, add 13 per cent. for loss of weight in water.

By loading the shield, therefore, with the weight required to produce any velocity, the deflector becomes automatic and will rise or fall as the pressure increases or diminishes, as in a scale beam. It becomes a simple matter, therefore, to produce any amount of pressure on the bottom by increasing the weight or counterpoise of the shield.

The shield may be supported by large floats or upon clusters of piles well anchored and guyed until their work is done, when they should be removed, either wholly or in part, leaving a portion of the lateral curtains, or their equivalent, to maintain the channel.

LATERAL DEFLECTORS.

Equilibrium of Curtains.

The equilibrium of the lateral system depends upon the two elements of weight and displacement; its stability upon the relation between the forces and resistances.

These conditions will be most clearly expressed in tabular form, but it should be distinctly understood that the computations are based upon the assumption that the forces press *normally upon a rigid surface,* which is not the case. The curtains are supported on the opposite side by the inertia of the water, and, being flexible, there is no severe *shock* or blow communicated to them.

Every part assumes its load gradually, and the stresses are of such a character as are best resisted by iron or steel in the form of ropes or chains.

It is also evident that should any one buoy or chain not be sufficient to uphold the system, others can readily be attached.

The unit of this calculation is a curtain 36 x 24 feet for deep water, with sufficient "play" for a tide of six feet.

Buoyant System.

Forces acting upward.

Name.	Volume.	Displacem't.	Weight.	Available Buoyancy.
1st Class Nun Buoy U. S. Standard	cub. ft. 253.32	lbs. 15,832.50	lbs. net. — 2572.30	lbs. 13,260.20
Stretcher 8″ diam., 40′	13.88	+ 862.58	— 1120.00	— 257.42
				13,002.88

Load (Iron).

Forces acting downward.

Name.	Dimensions.	Weight.	Ult. Strength.	Per Cent. of Loss by Immersion.
Main Vert. Chains.	$1\frac{5}{16}''$ diam. × 24′ *l*	388 lbs.	69,440 lbs.	13
Curtain Braces.	1″ diam. × 88′ *l*	120 "	24,000 "	"
	$\frac{2}{3}''$ diam. × 350′ *l*	210 "	14,000 "	"
Guy Chains.	1″ diam. 100′ *l*	1000 "	40,320 "	"
		1718 less 13 per ct. = 1495 lbs.		

If we omit the canvas covering, assuming it to have a specific gravity, when immersed, equal to that of water, we will have for total weight of buoy, stretcher, chains and attachments 5188 lbs., leaving an available buoyancy of 11,506 lbs.

The Moorings.

It is intended to anchor the lateral system to a ground cable laid upon the bottom and fastened at intervals to screw discs, sunk to a sufficient depth. Its efficiency has been abundantly

demonstrated at Calcutta, where it has been in use for some years for holding large vessels. These discs are sunk 25 feet and are spaced 420 feet apart (*Vide* p. 422, Vol. 34 of *Engineering*, Nov. 3d, 1882). In this article the author, Wm. Duff Bruce, M.E., C. E., says, § 75: "The whole of the moorings in the port are regularly examined by divers once a year, and since they were relaid in 1868 they have never shown the slightest sign of moving, although they have several times been severely tested." This was, therefore, after an interval of fourteen years.

Should the pressure of the waves and currents be sufficient to drag the buoys under water, there would result a pull on the anchorage of at least 11,506 lbs. This is equivalent to the weight of 260 cubic feet of moist sand immersed in water, and omits the pressure of the water. If, therefore, the discs were sunk but 10 feet, and the slopes of the cone of rupture be taken at 45°, the volume of the cone would be 1046 feet, or about four times the estimated pull. This multiplied by the available weight per foot, which I have taken as low as 60 lbs., gives 62,760 lbs. resistance, which is about equal to the strength of the vertical cables. As 60 is low, the chain would doubtless break before the anchorage would yield, and I doubt if any part of this system could well be subjected to a shock capable of rupturing a $1\frac{5}{16}$ in. iron cable.

The standard anchor cables for ships of 350 tons burthen are $1\frac{3}{8}$ in. in diameter. They are subjected to a much more violent action than this submerged system could ever be.

The experience then with moorings of this description appears to be amply sufficient to justify its application to this system of lateral curtains with every reasonable assurance of success.

Economy of Current Deflectors.

As to the economy of this method of dredging as compared with the mechanical devices, reference is made to a crude and limited construction used on the Garonne in France: where, notwithstanding its imperfections, it was found quite efficient. The account says: "An economical manner of removing the materials of the bed of a river consists in the application of movable dams attached to a boat. These dams offer a resistance to the flow of

the water, and, according to the greater or less depression given to them, they either divert the whole effort of the stream against any particular object, or by simply contracting the water-way they augment its velocity, especially at the bottom. Wherever applicable this system has been found to diminish the expense by about nine-tenths."

"The machine which was employed on the Garonne removed about 60 yards per day of sand and clay, at an expense of about 2¼*d.* (5 cents) per cubic yard."

(Extract from the "*Aide Memoire,*" Vol. 3, p. 273.)

It appears that this dam was a kind of vertical screen attached to the up-stream end of a scow to contract the water-way.

History of Vertical Deflectors.

Probably the earliest attempt made to apply a vertical deflection of the surface velocities upon the bottom was patented in 1853. The device consisted of a large, rectangular wooden tube, open at both ends and having a wooden diaphragm or inclined plane extending from the upper edge at the inner end to near the lower edge at the outer, for the purpose of reflecting the surface current downward to act upon the bar. "The excavator is to be anchored at the inner edge of the bar by weighting down the top." Thus it appears it had no means of locomotion, the anchorage was very deficient, there was no assurance that it would always remain "right side up" nor that it would not be submerged by the scour at its ends and sides. It would probably soon have been dashed to pieces or capsized.

In 1860 another attempt was made to apply this principle in a more practical device. It consisted of a floating barge having a false bottom hinged near the up-stream edge. The bottom was composed of two leaves, the lower being kept horizontal as it was pressed down by four spuds, while the upper was made to flare up stream to deflect the current under the boat and so wash out the bar over which it was placed. The action in this case, it will be seen, was limited and temporary and did not differ, in kind, from that of an ordinary scow, which being anchored over a shoal will cause the removal of the sand under it for a depth nearly equal to its draft.

A third device was that proposed by a Mississippi River pilot who tried to remove bars by placing a barge, having heavy scantling suspended on its side, athwart the current. Attached to the bottom of the scantling there were flaring shields 3¼ feet wide, extending the whole length of the boat, 80 feet, by which the currents near the bottom were deflected downward. This machine was placed at the upper end of the shoal to be removed, and the aprons lowered to the required depth, when it was found that the current was forced under it with increased velocity and the material was quickly excavated, thus allowing the barge to float down stream, guided by a tug, and shearing off the top of the bar as it went. "When a deepening of about six inches had been effected over the whole area required, the apron was lowered still deeper, thus shaving off the shoal by successive cuts." By this means a deepening of about two feet was effected, but when operations ceased the bar reformed. This serves merely to demonstrate the correctness of the principle of vertical deflection, for in this instance the feeblest currents or those near the bottom were the ones applied, and that only for a very limited depth. There was the fatal defect of not providing for a permanent change of regimen at that section, for no mere change of mould without a corresponding change in velocity will produce a permanent channel.*

Such are some of the devices proposed for vertical deflection of the maximum force of the current.

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* The Mississippi Jetties. Corthell, p. 216.

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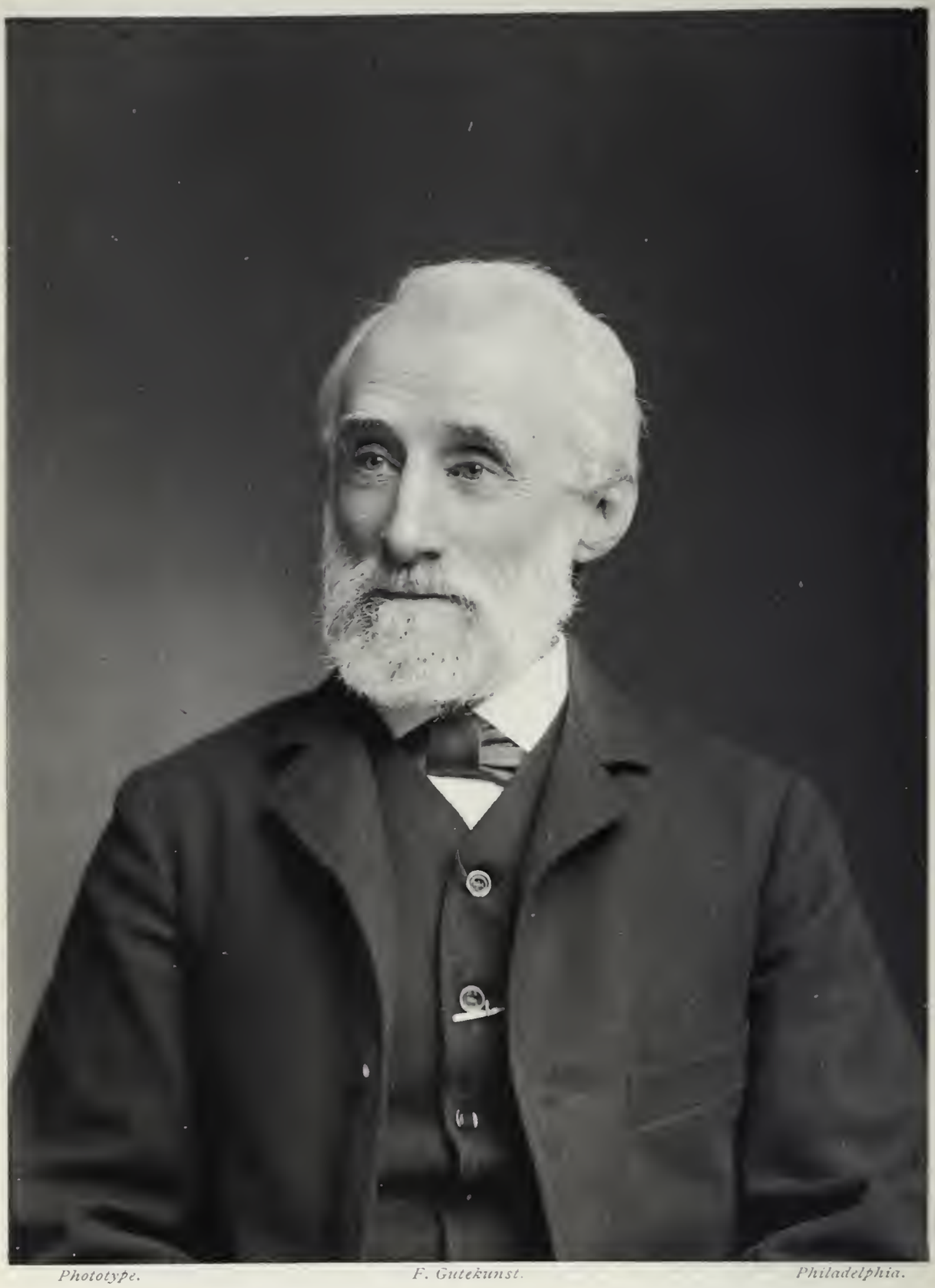

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Washington Jones

PRESIDENT DURING THE NINTH YEAR OF THE CLUB. A. D. 1886.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

NOTE.—The Club, as a body, is not responsible for the facts and opinions advanced in its publications.

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ANNUAL ADDRESS

OF

WASHINGTON JONES, Retiring President.

Read January 8th, 1887.

FELLOW MEMBERS:—This being the termination of our Club year, and the occasion when your officers resign to their successors the trust with which you honored them, and, as the event is usually accompanied by remarks upon matters of interest to the Club, I will try to fill that part of the proceedings which devolves upon the retiring President, although the task is not an easy one to present an address which will interest a body of Engineers in active practice and well informed upon current professional matters, unless the theme be:—new processes in the arts; the discovery of a new law in physics; personal experiences in a work of magnitude; an important invention; or some such novelty then first mentioned. When none of these are available, there remains but little beyond a passing notice of such prominent enterprises, begun or ended, as have been described in some of the many able technical periodicals found upon the tables of our library. Upon these items no doubt you are well informed, and therefore they are merely outlined here, as full descriptions might prove to be as wearisome as a "twice told tale."

It must be admitted by all with regret, that the hopeful anticipations of a revival in business activity, expressed in the last annual address read before you, and which were warranted by the auspicious opening of the year after a long season of depression, have not been realized. At that period, and for a short time after, the prospect was exceedingly good. New industrial establishments were projected and existing ones were to be enlarged, to meet the expected increase in the volume of manufactured products; but a check to growing confidence was given by the fears of national legislation adverse to manufacturing interests, then assuming a threatening aspect; and, in addition, a series of "strikes" were precipitated by inconsiderate workingmen, whose demands for greater remuneration or lessened hours of labor could only be acceded to upon the alternative not only of no legitimate returns for invested capital, but of the impairment of the capital itself. These causes produced their natural effect. The general business of the country was disturbed, and in some sections entirely paralyzed. No engineering work of importance was commenced during the early part of the past year, and only some which had been commenced previously were completed; but in the closing months of the year a reaction set in, and the lost ground was partially regained. The metal most important in the arts advanced materially in price, and that, observation has taught, is an almost unfailing sign of a revival in general business activity. Confidence is of slow growth, but it will be quickened and become strongly rooted when a plan shall be devised which will restore harmonious relations to the interdependents, Labor and Capital; and when returning reason shall awaken the workingman to the facts, that every man possesses the indefeasible right of free individual action, and that the most intolerable oppression known is the tyranny of a mob; and on the other side, when employers realize that a larger output and increased returns result from justly remunerated, contented labor, the first milestones on the way to a lasting settlement of the so-called "Labor troubles" will have been passed. The hum of spindles will be silenced by command no more, nor will the forge fire smoulder, whilst its master sits in enforced idleness awaiting permission to resume the toil that brings food to wife and eager little ones.

Nor will the railway train, bearing the products of the farm and mine, be again arrested when on the way to exchange its burden for another needed at its starting point. Capital will expend its surplus upon new enterprises, knowing that the hand of Labor will gladly lend its skill for the mutual advantage, and "there shall be none to make them afraid."

In recalling your attention to such engineering works as have come to my notice, I shall place them in the order of their seeming importance in promoting the interests and comfort of mankind.

In a country like our own, possessing a diversity of climate and soil, and so producing nearly everything necessary to supply the wants of its inhabitants, railways, for the interchange of its products, should rank first.

It has been remarked: "The railway traffic of the United States far exceeds in value its foreign commerce." This should cause no surprise, when it is considered that the bulk of our imports and exports must be carried by railways from or to the shipping ports, excepting only that portion of imports consumed in those ports, which, manifestly, does not nearly equal the remainder to be transported for inland consumption. During the past year the total mileage of railway in the United States was increased by eight thousand (8,000). Of this about one hundred miles in length was laid by the Baltimore and Ohio, from Baltimore to Philadelphia, intended as a link to connect with the Reading Railroad and its leased lines through to New York. Another road, somewhat longer, has been built from Philadelphia up the Schuylkill Valley into the anthracite coal regions. As both these roads are closely parallel with other long existing roads, and therefore do not develope new territory, the necessity for their construction is not apparent. The greatest activity in railway building has been in Kansas, over 1,500 miles having been laid. Texas with over 200 miles; Wisconsin about 200 miles; Illinois, 175 miles, and less amounts in several of the Northwestern States. The first through train to Vancouver, over the Canadian Pacific Railway, started in July, 1886, and consisted of 12 cars. One hundred and forty passengers were carried. This is the fourth railway across the Continent. Not

many years ago one was considered as the idle fancy of an enthusiast.

The Russian government again has under consideration the scheme for constructing a railway across the Caucasus. Its total length will be about 121 miles, of which over 9 per cent. will pass through tunnels, the longest being about four miles. It is expected to be of great commercial as well as strategic value to Southern Russia.

A railway is to be built in Africa extending 250 miles from Loando, on the west coast, into the interior. Its bonds are to be guaranteed by the Portuguese Government, and its equipment is being made in Belgium.

The total railway mileage of the world, at the end of 1884, is estimated to have been 290,750 miles. Of this 60 per cent. is in English speaking countries. Its total cost is estimated to be $24,000,000,000. The cost per mile ranges downward from $205,-840, in Great Britain, through Belgium, France, Germany, Austria, Russia and lastly the United States, where the cost was only $63,250.

Tehuantepec Ship Railway is to be urged forward by an appeal to private capitalists. The promoters have declined the aid of Government, trammeled by its restrictions; but Congress will be asked to charter the new organization, which will be a private company, international in its scope and membership.

When the civil engineer has completed his work upon a railway line, from its location to final track-laying, the services of the mechanical engineer comes into requisition to supply the motive power. That he is equal to the occasion is proved by the fact that after our own roads are fully equipped, a surplus of locomotives, valued at $3,000,000, are exported annually. One firm in this city turns out each year 600 engines, or two for each working day, a larger production than that of any other establishment. Such railway companies as have suitable workshops prefer to build themselves engines of their own special design, but all have the distinctive features "that the process of evolution has developed into the American type," one that is admirably suited to its work and satisfactory to railway managers, notwithstanding the unfavorable judgment passed upon it by the advocates of other types.

The rank of European countries in their yearly production of locomotive engines is:—Great Britain, 2,200; Germany, 2,000; France, 1,000; Belgium, 500; Austria, 400; Switzerland, 120; Italy, 70; Sweden, 50; Russia, 40; Holland, 20. Total, 6,400.

Bridges.

Now that railway trains have reached almost to the limit of speed attainable, and probably nearly to that of safety, the traveller chafes if a minute of his time be lost through running at a slower speed. In the *olden time of twenty-five years ago*, whenever a railway track was interrupted by a navigable river, the trains were ferried across upon a steamboat, unless the winter's solid ice prevented, but gave instead a road bed for a temporary railway track. But, in the present day of ceaseless activity and haste, no such waste of time is tolerated. The intervening water must be crossed at speed; preferably over it upon a bridge. Should a bridge be impracticable, then under it through a tunnel. Of these modes of transit, now in course of construction or projected, the following may be named as of importance:

Poughkeepsie Bridge, for which the final contracts with the Union Bridge Company for its construction have been signed. It is intended to cross the Hudson River at Poughkeepsie, and will be of steel, with four spans, each of 525 feet in length. The masonry piers will be carried up 30 feet above the water, and will sustain superstructures of steel 135 feet high, upon which the bridge floor will rest and form a carriage way. The deck of the bridge will be 55 feet above the floor, and will carry a double railway track, over which a large traffic is expected to be passed, as it will be the only bridge crossing the Hudson River below Albany. A bridge of the cantilever pattern for the new St. Paul railway is being built to cross the Missouri River at Kansas City. It will be 200 feet long, and elevated 80 feet above the water.

By the courtesy of Mr. S. S. Smedley, Chief Engineer of the City of Philadelphia, I am enabled to read the description of "the new highway bridge now being erected over the Schuylkill River on the line of Market Street, Philadelphia. It will be an iron structure, on the cantilever principle, 77 feet in width and 550 feet in length, resting upon the old foundations entirely, except the

anchorage or shore piers, which are wholly new. The old river piers are to be removed to low water line and built up anew to eight feet above high water. The old abutments have been partly removed, rebuilt and arranged to suit the proposed new work. The river portion will be five lines of single intersection trusses, containing ten double cantilevers and five suspended trusses. The cantilevers are 167 feet in length and 22 feet in depth at piers, and nine feet at ends, which is also the depth of the suspended trusses. The river piers are 215 feet apart between centres. The shore spans each have plate girders 64 feet in length. The roadway is formed of transverse **I** beams covered with buckled plates, upon which is laid asphalt composition wearing surface on the roadway, and granolithic concrete on the footways. Provision is made for the passage of the grip and cable of the Traction Railway, and also for gas and water mains and electric cables under the roadway. The roadway at middle of river will be 34 feet above high water, and about three feet lower at the abutments. The contract price, exclusive of engineering, etc., is $271,000. The work has been delayed by causes incidental to city operations, but is expected to be completed before the close of next autumn."

A bridge of iron and steel to cross Harlem River at Tenth Avenue, New York City, has been determined upon and the contract given out. It is to be completed ready for traffic by July, 1888. The central span will swing, to allow masted vessels to pass. Its length will be 508 feet, width 80 feet, of which 50 will be carriage way, and 15 on each side will be footways.

Hawksbury Bridge is in the line of the Southern and Northern Junction Railway of New South Wales, a first-class double track road, which runs from Sidney to Newcastle, the two principal business centres of the Island, and it crosses the Hawksbury River at a point where its width is such as to require a total distance of nearly 2900 feet between the abutments. The conditions stipulated that the clear headway above the water should be 40 feet, that the superstructure should be of steel, and that the piers should be based at a prescribed depth, which, for some, is 170 feet below water level. Fourteen bids were received, and their amounts varied from $1,481,750 to $3,511,920, and the times for completion

from two to four years. The contract was given to the Union Bridge Company of New York, upon the approval of a Committee of Engineers appointed to select the best design, and by Sir John Fowler, the consulting Engineer of the company, who decided the Union Bridge Company's proposal to be the most economical, and its design met their views of stability. It consists of seven spans, each 415 feet long, of a truss through bridge supported by caissons 24 by 52 feet, rising to the water line, and by columns 40 feet in height to the bridge floor.

Forth Bridge. In the fourteenth quarterly report of inspection, the engineers say: "The works have made rapid progress during the last three months, and we have every reason for continuing to be satisfied with the way in which they are being executed."

A project is under consideration for tunnelling the Rocky Mountains under Gray's Peak, the narrowest part of the backbone of the Continent. The length of the tunnel from east to west, at points 10,000 feet above sea-level, will be 25,000 feet, and its use will shorten the railway distance between St. Louis and San Francisco about 300 miles.

Since the completion of the St. Gothard tunnel, the exports from Germany, Italy and Switzerland have nearly doubled.

There is a probability that the proposed tunnel under the Straits of Messina will be made, to join the railways of Southern Italy with those of Sicily for commercial and military reasons. Its cost is estimated at $14,200,000, its length eight and a half miles, and the time for construction from four and a half to six and a half years. It will be 500 feet below sea level, and the entrances are to be reached by spiral approaches.

A railway tunnel between Denmark and Sweden is projected by the Governments of the two countries, to connect the cities of Copenhagen and Malmo. Its length will be about seven and a half miles, and the cost is estimated at $6,000,000.

Severn Tunnel, the connecting link of the Great Western Railway system, between Gloucestershire and Monmouthshire shores of the Severn estuary, has been opened lately for passenger traffic. It was commenced in March, 1873, or nearly 14 years ago.

Panama Canal.

Of this gigantic undertaking the published statements are so conflicting that no positive idea of the condition of the work, or the time of its completion, can be entertained. Its advocates report rapid progress of the excavation, and assert that the time originally set for its opening to trade will not be exceeded. On the contrary its decriers predict a disastrous collapse to what they term a doubtful and extravagant enterprise. M. Rosseau, who inspected the Canal in the interest of the French Government, admits that its success depends upon contingencies of a grave character, whilst a technical commission has expressed its conviction that the obstacles to the completion of the work can be overcome. No doubt the Canal will be finished eventually. So large an amount of money has been expended upon it, that to avoid a financial disaster the work must be completed; if not by the present Company it will be by some other. M. de Lesseps' report on the Canal shows the net expenditures from the commencement to the 30th day of June, 1886, was 471,000,000 francs. The amount of shares and bonds is 712,000,000 francs, leaving a balance of 241,000,000 francs in unpaid instalments on shares and bonds and other assets. The Canal Company will probably issue a further loan.

Manchester Ship Canal.

The contract for making this Canal, which was fully described in the last address delivered before you, has been awarded for the sum of £5,750,000, or very much less than the estimated cost, and its construction is now assured.

The Canal, for which the German Bundesrath approved the bill, will connect the Baltic with the North Sea, and will run from the mouth of the river Elbe to the river Eider, and along that stream to Rendsburg, thence along the present Eider Canal to the Baltic at Maltneau. Locks will be required at the ends only. The surface width will be 185 feet; bottom width 80 feet, and depth 25 feet. Its capacity will be sufficient to admit the passage of the German ironclads.

It is proposed to connect the Sea of Azof with the Black Sea

by a canal of 65 feet in width and 12 feet in depth. By its use the passage from sea to sea will be shortened about one hundred miles.

In the line of municipal engineering, Water Supply is for many reasons the most far-reaching and important. One of the largest plants of this character has been put into operation lately by the Amsterdam Water Company, at Weesp. The supply is obtained from the river Vecht, an outlet of the Rhine to the Zuyder Zee, and it will be conveyed through a 48-in. main about three miles to the pumping station, which is equipped with ten boilers and two pairs of beam compound engines, moving four low lift and four high lift plunger and bucket pumps. Each low lift pump has a capacity of 183,500 gallons per hour, and raises the water into settling reservoirs of 18,000,000 gallons capacity; from these it passes through filter-beds into a series of covered reservoirs, from which it is taken by the high lift pumps, whose capacity is 161,-300 gallons per hour, and forced into stand-pipes against a total head of 230 feet. There is a double system of delivery, in which one set of mains, 24 in. diameter and about seven miles long, is to deliver pure water to domestic users, and the other set of mains, 27 in. diameter, is to deliver river water for manufacturers and public use. There will be about 120 miles of distributing pipes, and no less than 100 canals must be passed under by them.

The City of Genoa proposes to build water works. The reservoir will be about eight miles distant from the city, and will have a capacity of 150,000,000 gallons, which is sufficient for 30 days' consumption.

Work on the new Glasgow Water Works is progressing satisfactorily. When completed the present supply will be doubled.

In the United States the inhabitants of small towns and villages are becoming aware of the important bearing an abundant supply of pure water has upon health, and over two hundred and fifty plants of water supply are now being constructed in various States. In our own city the most pressing need is—more and purer water. Recognizing this fact, the municipal authorities adopted the recommendation made by Col. Wm. Ludlow, when Chief Engineer of Philadelphia City Water Works, and ordered a survey to determine the best source of supply. This was made

by Mr. Rudolph Hering, Engineer in Charge, and a corps of assistants. The results of his work are embodied in the report of Chief Engineer John L. Ogden to the Water Committee of City Councils. The survey includes an area of 446 square miles, in the Counties of Bucks, Montgomery and Lehigh. The report contains a comparison of several water-sheds as to their physical and sanitary features, the maximum and minimum amount of rain-fall upon those available, situated within a radius of 150 miles from the city, and other data necessary to reach a conclusion. The author expresses the opinion that at the present time the most economical plan is the "Point Pleasant Scheme," which contemplates the conveyance by gravity of the supply of 90,000,000 gallons per day available from Tohickon Creek, and the pumping by water power of 120,000,000 gallons at Point Pleasant, on the Upper Delaware River, thus making a total daily supply of 210,000,000 gallons. This plan includes an aqueduct of 12 feet diameter, which it is proposed shall be continued eventually up the Lehigh or Delaware rivers to impounding reservoirs. The report shows that the required supply for the city, 200,000,000 gallons daily, cannot be had from any one source except the Lehigh or the Delaware. The latter river, at Point Pleasant, below its junction with the former, its largest tributary, has a minimum flow of 1,500,000,000 per day. It is unfortunate that the lack of funds prevented the extension of the survey when in such capable hands, so as to include the water-sheds of Monroe and Pike Counties, draining into the Delaware above the Water Gap, as they are in a mountainous region, sparsely settled, having but 25 persons to a square mile, and are heavily wooded. The general conclusions of the Engineer in Charge are, in his own language: "It "required but little thought to see that the water from the streams "north of the Blue Mountains would be the best available in "quality, not only now but for an indefinite future, and that this "region would therefore have to be the ultimate source of water "supply to Philadelphia, and probably also for other cities lying "between the mountains and the seaboard."

In this connection it seems proper to quote the findings of the Master in the equity suit of the City to restrain the pollution of the Schuylkill river, our present main source of supply: "The

"statutes against pollution and the stipulations in the contract "with the Schuylkill Navigation Company as to its lessees at Flat "Rock are explicit, yet because their enforcement would affect "injuriously large manufacturing interests they have become "dead laws. So long as the City itself, by reason of the drainage "of its sewers, streets and properties, continues the chief offender "against the law, it is idle to expect private property owners to "give it voluntary obedience." It is reasonably expected that the intercepting sewer will carry off the impurities discharged into the Schuylkill from its left bank, including Manayunk and Fairmount. The following description of the sewer and its present state of forwardness is due to the courtesy of the Chief Engineer of the City:

Manayunk Intercepting Sewer.

"During the year 1886 the Manayunk Intercepting Sewer has been extended from Falls Village to Manayunk, a distance of 11,787 feet, 19,271 having been previously built, $144,000 having been expended this year. The average cost per foot has been $13, which includes an expensive stone dam across the Wissahickon Creek, through which the sewer is carried, and flushing gates, by which the Wissahickon water can be thrown into the sewer under a head to wash it out thoroughly when required. The total expenditure to this time is about $400,000. This sewer is part of a system which is intended to be carried along the east side of the Schuylkill river to its mouth, so as to intercept all the city sewage now flowing into the Schuylkill river on the east side.

From the Delaware river to Fairmout dam, the limit of tide water, the distance is 40,000 feet, and from there to the Flat Rock dam above Manayunk is 39,000 feet.

The part of the intercepting sewer now being constructed extends from the tidal stream at Fairmount dam to Manayunk, and is projected to keep the liquid filth and refuse of the manufactories at Manayunk and sewage from the drainage area from contaminating the drinking water of Fairmount dam, from which the city water supply is obtained.

The outlet near Fairmount Water Works is a submerged

wrought-iron pipe, extending to the centre of the river. The sewer is circular $4\frac{1}{2}$ feet in diameter, commencing at Fairmount Water Works at an elevation of seven feet above ordinary high tide, and running with an uniform grade of four in 10,000, or $2\frac{11}{100}$ feet per mile for 25,000 feet to Wissahickon Creek. From Wissahickon Creek to Manayunk the diameter is four feet, with a grade of $3\frac{7}{10}$ feet per mile.

It is then carried by a 42-inch iron pipe under the bed of the Schuylkill Navigation Company's canal, where the bottom elevation of the sewer is 20 feet above high tide.

A branch sewer, running up the Wissahickon Creek to intercept the sewage from the western part of Germantown and Chestnut Hill, is being built, and also a separate system at the Falls Village; the small pipes leading into the intercepting sewer, and the large storm water conduits into the river.

The sewer is smoothly plastered inside with Portland cement, and the grade is sufficient for a self-cleansing velocity of three feet, and a discharge of 48 cubic feet per second.

Surveys for this sewer were made by the Commissioners of Fairmount Park in 1869, and a sewer seven feet in diameter was suggested at an estimated cost of $1,200,000. Although the pressing necessity for the sewer was constantly urged, the financial reverses of 1873 prevented any appropriations being made until 1883, when it was determined to appropriate $100,000 per annum to this work. In order to avoid the constant expense of pumping and to carry out a gravity system, a very light grade became necessary for a great distance along the river shore, so as to be low enough to reach the factories and pass under the canal.

The whole drainage area involved within the city limits is 11,000 acres, a great portion of which is very high and hilly, the summits being 400 feet above tide, and the hills along the shore are so precipitous that there are only 850 acres outside of Park limits available for improvement below the contour of 100 feet above high tide.

To suffer all this drainage to descend rapidly with enormously excessive grades to the bottom of the valleys, thence to be carried for a great distance at the lowest admissible grades, is injudicious; because ten times the amount of grade, that is, 20 feet to the mile,

instead of two, can be obtained for 90 per cent. of the territory, and a sewer of given capacity and cost will carry twice as much sewage under the higher grade.

Owing, also, to the difficulty of raising sufficient funds to complete the work at an early day, it was considered more economical and prudent to build the sewer of sufficient capacity to provide for factory drainage and sewage for the growth of population for fifteen or twenty years, after which time higher level sewers can be built to carry off the drainage of the higher territory, leaving the valley sewer entirely for the manufacturing territory along the river. The benefits of the smaller sewer will be secured in one-half the time, at one-half the cost; another sewer of the same size, with a heavy grade, will do the service of one of double the capacity, as originally projected, and the money saved thereby and the interest accruing will save to the city a fund sufficient for more extensive work.

For the factories and sewage adjacent the sewer will be available for use within a few months."

Railways.

The growth of many American cities has been greatly stimulated by the introduction of street railways, and the extension of their area has compelled the consideration of a more rapid mode for conveyance of passengers to the business centres than that obtained from animal power. The first advance in that direction is cable haulage. This plan was put into successful operation first in San Francisco several years ago, upon a line with gradients so steep as to be insurmountable by horses; and afterwards in Chicago, St. Louis and some towns of smaller size. In Philadelphia the Traction Company have portions of their lines operated by cables with only a tolerable measure of success; but it is a problem yet to be solved whether that plan of moving city railway cars over level streets is equal or superior in efficiency and economy to that of animal power. Mr. Sanson, a French scientist, says: "On a comparison of animal and steam power it is found "that in France the former is the cheaper. In the conversion of "chemical to mechanical energy, 90 per cent. is lost in the "machine, and 68 per cent. in the animal." On the Mount Par-

nasse and Bastile line of railway he found the cost for each car to be 57 francs for traction, and for the same work done by animals the cost was 47 francs. Where the conduits are level, or so little inclined that storm water and street dirt falling through the slot for the grip arm will not drain to points accessible for its removal, the difficulty of cleaning will cause an expense which must be incurred to avoid clogging of the cable-supporting sheaves, even if the offensive odors arising from the decaying matter be disregarded. The slipping of the cables through the grip when cars are slowing down, or starting, must cause rapid wear upon them. Those used upon the San Francisco roads are manufactured in the railway company's own works, presumably in the best manner, and their life is from eight months to two years only. The supporting sheaves, also, will wear rapidly where the cables rest upon them, for, as their circumferential velocity cannot equal the linear velocity of the cable, abrasion must ensue. The renewal of the conduit, when rusted out, will require an expenditure of considerable magnitude and a cessation of travel, or the use of animals, until the repairs are completed.

Kansas City has a short cable railway laid in one of its principal streets, having very steep gradients. It is upon elevated ground, and no doubt the conduit can be kept clean by flushing, so that there one source of trouble can be avoided.

Experiments are still being made to determine the practicability of moving city railway cars by electricity. In Philadelphia, New York, Brooklyn, Scranton and several other towns short test lines are in operation. One in Minneapolis, about one mile in length, is equipped with a motor of 40 horse-power, which draws a train of four cars carrying 600 persons, and which has a total weight of 91 tons, in about nine minutes, including stops, per mile.

The Electric Locomotive and Power Company of London have built an electric locomotive upon the system of Mr. E. P. Elieson, in which the armature shaft is connected to the driving wheel axle by gears. The storage batteries have a capacity sufficient for a run of six hours' duration.

Whilst upon this subject, appropriate mention may be made of further tests to demonstrate the applicability of electricity to

marine propulsion in the trial of the "Volta," a steel boat of 31 feet in length and 6 feet 10 inches beam. The propeller is 20 inches diameter and 11 inches pitch, mounted on a shaft which is coupled direct to the armature shaft of a Duplex Reckenzaun motor. Its revolutions can be varied at will from 600 to 1000 per minute, and the vessel moved forwards or backwards by the movement of a single switch. The storage cells weigh about two tons. A voyage was made from Dover to Calais and back with ten persons on board. More time was consumed than desirable, but in other respects the performance was satisfactory.

The New York District Railway Company is applying for permission to lay a system of railways under Broadway. Warned by the failures of its predecessors of 1868, 1873, 1881, 1884, 1885 and 1886, which were severally vetoed by the Governors then in office, the present applicant has given some consideration to the rights of the property-holders on the street, and does not intend to encroach upon them. The present scheme contemplates the excavation of Broadway from the Bowling Green up to Union Square, thence to Madison Square, where it diverges; one branch following Madison Avenue to and under Harlem River until a junction is made with the suburban railways and other railways running north and east. The other branch continues in the line of Broadway to Fifty-ninth Street and to Eighth Avenue. The method of construction will be as follows: strong walls are to bound the existing vaults now under the footways on each side, about 44 feet apart, the entire width of the roadway. Between these are to be six galleries formed by building thin partitions of a special material. Four of these will be occupied by railways and two by water and gas-pipes, sewers and electric wires. The foundations will be of concrete and the roof of buckle plates, supported on beams and covered with asphalt and concrete. The approaches to the passenger stations will be from the side streets by stairways of gentle inclination.

The Metropolitan Railroad Company of Philadelphia has applied to Councils for permission to construct an underground railway within the city limits. It is to run from Upper Darby to Chelten Hills, and a cross-line is to extent from Sixty-third and Market Streets to the City Hall, where it branches on Broad Street

north to City Line Road, and south to Government Avenue. The main stem makes a detour to pass the City Hall and re-enters Market Street and continues to the Delaware River. From Market Street several branches run north, north-west and south. Stations will be located at convenient points and will be reached by stairways. The subways will be 15 feet in height by 23 in width, or sufficient for double tracks. The roof will be supported by the walls on the sides and by a row of iron columns in the middle carrying brick arches. Electricity will be used as a motor and for illuminating. It is stipulated that the construction of the road shall not interfere with street travel. Such portions of the road that run through the rural districts shall be open cuts, but they are to be covered in when the city authorities shall so direct. The subway roads possess advantages over the elevated roads, as they offer no obstruction to street traffic, cause no annoyance by noise, falling cinders or smoke, and will not deteriorate the properties on their route. In the year 1885 the six Metropolitan Underground Railways in London, whose population at that time was nearly 4,000,000, carried 224,000,000 passengers, or over 55 travelers per head of population.

It is estimated that the elevated railways of New York City carried 175,000,000 passengers during the last year. This is an increase of 70,000,000 over the number carried in 1885. The reduction in fare has secured an increased patronage of 200,000 passengers per day, and the maximum carrying capacity is nearly reached.

Congress has authorized the construction of 18 vessels for our Navy, with their hulls entirely of metal. Seven of the ships are to be armored, the heaviest with steel of 16 inches thickness. Some of them will be protected cruisers with lower decks of steel, rounded so that their junction with the sides falls below the water line, thus protecting machinery and magazine from shot and shell. There are to be also four steel cruisers, two gunboats and some torpedo boats. It is also determined to complete the five armored vessels of the double turret Monitor class for coast and harbor defense. Should occasion require, these latter can be sent to sea, their seaworthiness having been thoroughly tested. Of the proposed number, contracts have been made for one cruiser

of 4,000 tons displacement, and fitted with machinery to develop 7,000 horse-power minimum and 8,000 maximum; one cruiser of 3,700 tons displacement, and machinery of 6,000 horse-power minimum and 7,000 maximum; one gun-boat of 1,700 tons displacement, and machinery of 2,500 horse-power minimum and 3,000 maximum; one light gunboat of 870 tons displacement, and machinery 1,000 horse-power minimum and 1,100 maximum. By the terms of the contract the sum of $100 will be added or deducted for every horse-power developed over or under the maximum. Should the horse-power fall below the minimum the vessel may be rejected. It will be noticed that the required horse-power is unusually high, but it is of the first importance that speed shall be assured. A stipulation of the contract requires all the material to be of native production. At present we have no forges equipped with tools of sufficient capacity to make the armor-plates, guns or shafts for the larger ships, simply because there has been no market. Should a constant demand arise for such products it can be met, for our materials and workmen are of the best, our manufacturers of iron and steel are enterprising, and if they were reasonably sure of a continuance of orders, no doubt plants commensurate with the requirements would be put down.

The contest between armor and guns appears to have resulted in favor of the latter. When guns are made of 119 tons weight, capable of throwing solid shot of 2,300 pounds with a muzzle energy of 50,324 foot tons, it becomes doubtful whether a ship of the ordinary type, standing high from the water-line, can be armored so heavily as to resist penetration, and yet be seaworthy and manageable. The partial or total failures of several European, as well as of our own war vessels, in some essential feature has warned us to go "slowly and surely;" and, as our need for a navy is not so pressing as it is for those countries who are either at war or preparing for it, or who have distant colonies to protect, we could afford to wait for the development of the best types resulting from the experiences of other countries. These now seem to be torpedo boats—the sharp-shooters of the sea—comparatively insignificant in size and cost, but terrible in their destructive effects, from which there is no other avoidance than flight. Or,

the cruiser of high speed, armed with guns of long range and able to choose her position; to overtake or to retreat from an enemy. Perhaps the dynamite gun cruiser now building may prove to be one of the highest order of war vessels. Should it be so, we may claim to have contributed to the science of naval warfare three means:—The Torpedo, the Turretted Monitor and the Dynamite Gun Cruiser. May they nevermore have other than experimental tests.

Congress at the last session appropriated the large sum of $14,000,000 for the improvement of our harbors and rivers, the expenditures to be mainly for the construction of jetties and the preservation of existing works. Of this sum about three and a-half millions are for the Mississippi River, and 800,000 for the harbor of New York.

An eminent writer on political economy has said, "Everything of value comes out of the ground." As food products necessarily are of the first importance, the second place must be given to those metals and minerals which are most urgently needed in the arts. By the report of the United States Geological Survey, which includes the years 1882 to 1885, the production of pig-iron diminished from 4,623,323 tons in 1882, to 4,044,525 tons in 1885. This quantity for the year 1886 was increased to 5,600,000 tons.

The production of copper during the same period has increased from 91,646,232 pounds to 170,962,607 pounds, or 76,306 tons. Of this metal the United States produces more than any other country. The next in order is Chili, 38,000 tons; Spain and Portugal yield 45,000 tons; Germany, 12,000 tons; Australia, 11,000 tons and Japan, 2,000 tons. Of lead the United States produced in 1882, 132,890 short tons, which quantity was diminished to 129,412 tons in 1885. The production of the precious metals in 1882 was, gold, 1,572,186 Troy oz., of silver, 36,197,695 Troy oz., and in 1885 the production of gold fell to 1,538,176 Troy oz., whilst silver increased to 39,910,279 Troy oz. Of the minerals, bituminous coal leads in quantity. The amount mined in 1882 was 60,861,190 tons, which in 1884 increased to 77,417,066 tons, and in 1885 fell to 64,840,668 tons. Of anthracite, the quantity mined in 1882 was 31,358,264 tons, which was increased in 1885 to 34,228,548 tons.

Petroleum from 30,053,500 bbls. in 1882 fell to 21,842,041 bbls. in 1885, a falling off due to the lessened quantity exported to Europe, where the demand is largely supplied from the oil region of Southern Russia, in which it is reported that one well is spouting 2,750,000 gallons per day to a height of 224 feet.

South Carolina phosphate rock shows a steady increase of production from 332,079 tons in 1882 to 437,500 tons in 1885. Of the less important products of the mines, some have increased whilst others have diminished. Of the emission of natural gas no quantities are or can be given, but its value in 1882 is stated at $215,000, which increased rapidly to $4,854,000 in 1885. It is assumed that the values named are based upon the rentals paid by users for quantities consumed, but it is evident from published accounts much more is uselessly than usefully burned, or permitted to escape free into the air. A notable verification of the adage, "Great abundance is the parent of waste."

In the United Kingdom of Great Britain the production of pig-iron during the first six months of 1886 amounted to 3,536,774 tons, which does not equal that for the corresponding period of 1885 by 270,321 tons, and the consumption fell off 367,813 tons.

There is nothing which more distinctly emphasizes the utilitarian spirit of the age and its disregard of sentiment than the scheme to use as a motor the waters of Niagara Falls—one of the grandest and most stupendous natural objects in the world. For this purpose a company has been organized to build a tunnel for the conveyance of the water from a point about one mile up the river from the crest of the fall to the water-level at the foot. Enough land along the line of the tunnel has been secured to accommodate over two hundred mills, sufficient to absorb 119,000 horse-power, the estimated capacity of the tunnel.

The completion of the bronze statue of "Liberty Enlightening the World," the gift of the French people to the people of the United States, erected in the harbor of New York City, and its unveiling, attended with impressive civic and military ceremonies upon October 28th last, was an event which, though not wholly within the domain of Engineering, should by no means be omitted from mention.

"The land that from the rule of Kings,
In freeing us, itself made free,
Our Old World's Sister, to us brings
Her sculptured Dream of Liberty.

The colossal height of the statue—over three hundred feet above the water, and its weight of two hundred and twenty-five tons, requires a substructure of massive proportions, and its exposed position upon an island in the bay demanded that the materials composing it should be of the most enduring qualities. This portion of the work, and the assembling of the details of the figure and its anchorage, was entrusted to an accomplished engineer, who no doubt, time will prove, has well performed his task. Let us indulge in the fervent hope that no international or elemental disturbance will ever come to endanger the permanency either of the fraternal feeling existing between the two Republics, or of the noble gift which is its tangible evidence, and that both may endure "until time shall be no more."

In conclusion, let me add a few words about ourselves. The growth of the Club has been steady, and beyond that usually found in one of its years.

Following the simile of an honored past President of our Club: the "infant" has survived the perils that beset infancy, passed through the period of adolescence, and now has "taken on the garb and stature of a man," standing firmly and erect.

Increased strength and amplitude can be assured by proper sustenance;—a continuance of the sound work done in the past.

The papers read before us and the discussions they elicit are so interesting and instructive, that an increase in their number is greatly to be desired. Our quarters are attractive and comfortable, and need but little more to make them all that need be wished for; their central location and facility of access are conditions of especial advantage. They are so commodious that many more members would find room. These good qualities, if presented to eligible persons, should incline them to join us, and assist in extending the sphere of the Club, not only by increasing its revenue, but by the more desirable contributions of professional matter. The founders of our Club were wise in not restricting its membership to those who cultivate one special field in the ever widening

domain of Engineering; in disregarding the dividing lines and inviting free intercourse and the co-operation of all in the advancement of the general knowledge in that most comprehensive science. Thanking you for the uniform courtesy and aid you have extended to me in the performance of my duties, and expressing my sincere wish for the continued prosperity of the Club, I now vacate the Chair about to be so worthily filled by my successor.

OPENING ADDRESS

OF

THOMAS M. CLEEMANN, President,

ON TAKING THE CHAIR FOR 1887.

Presented January 8th, 1887.

GENTLEMEN:—I thank you very much for this honor. In the discharge of my duties I shall endeavor to merit the confidence that you have reposed in me, and I trust that the close of my administration will see the Club in an even more prosperous condition than it is in on my entering it. It has had no vicissitudes as yet, and when I reflect on the worthy men who have preceded me, whose portraits look down upon us, how their government has placed us where we are, I feel some diffidence in following them, and I shall perhaps need a little indulgence from you to aid me in keeping up our high previous standard. We have been distinguished, I think, from other Engineering Societies in our Active Members being younger men, still possessed of the enthusiasm of youth in their profession. This, I hope, will continue. It lies with you, gentlemen, to keep up the infusion of new blood, and each should do his part toward increasing our membership with the brightest of the rising young men, the coming heroes in the conquest of the laws of nature for the convenience of man.

Let us now proceed to business.

XII.

THE DRAINAGE AND WATER SUPPLY OF CHICAGO.

By Rudolph Hering, Active Member of the Club.

Read December 4th, 1886.

The City of Chicago obtains her water supply from Lake Michigan. The intake is two miles from the shore, and the water brought to the city by a pair of tunnels, five and seven feet in diameter, driven through the clay which underlies the lake. The average daily consumption as recorded for the last year was 91,650,000 gallons, the supply per head being 137 gallons. The water of Lake Michigan is generally of excellent quality. Occasionally, however, it is rendered undesirable as a drinking supply in the immediate vicinity of the intake, from two causes. The action of the waves during stormy weather reaches down nearly sixty feet, somewhat deeper than recorded of the ocean, which is due possibly to the lighter specific gravity, and therefore greater mobility of the water. The clay of the bottom is, in consequence, disturbed, and the water is made roily, which more or less discolors the water supply to the city. The other and more important cause is the danger of an occasional sewage pollution from the Chicago River. To devise the best means of guarding against these troubles is the purpose of the investigation now being made.

The city is at present well supplied with good sewers, designed and mostly built under the direction of the late Mr. E. S. Chesbrough. Nearly all the sewage is discharged into the main river and its branches which run through the city. The natural summerflow of these streams is very slight; in fact it becomes practically nil. The sewage would, therefore, gradually replace their water and tend to convert them into huge cesspools, the contents of which would be belched into the lake by the flood waters carried by the river after every storm. By fortunate topographical conditions, however, this state of things has not become serious, and the pollution of the lower river and the lake is now but rarely noticeable. About ten miles west of Chicago is the

divide between the Mississippi River and the great lakes. It is only about ten feet above Lake Michigan, and is crossed by the Illinois and Michigan Canal, the lake level being its summit level. Thirty miles west it begins to descend, and finally reaches the Illinois River. Into this canal the sewage of Chicago is discharged to-day, and finds its way ultimately into the Mississippi River instead of into the lake.

If the quantity of sewage were small, that is, not greater than from a city of two or three hundred thousand inhabitants, this disposal would be quite satisfactory. But Chicago is growing at a remarkably rapid rate, its water supply is large per head of population, and the quantity of sewage is, therefore, so great that the discharge into the canal causes to-day a nuisance for many miles below. With its suburbs Chicago now has a population of over eight hundred thousand. Its rate of growth since 1880, as determined from the school census taken every two years, is such that it will overreach Philadelphia in about five years, and then be the second largest aggregate of population in the Union. The unbounded supply of good water at its side, and the comparative economy of distributing it, produces a very large consumption, and clearly indicates a large quantity of sewage to be provided for in the future.

The possible ways of disposing of it are three:

1. Intercepting sewers may collect and bring it to certain points from where it may be pumped through conduits several miles out into the lake, delivering as far from the intake of the water supply as practicable.

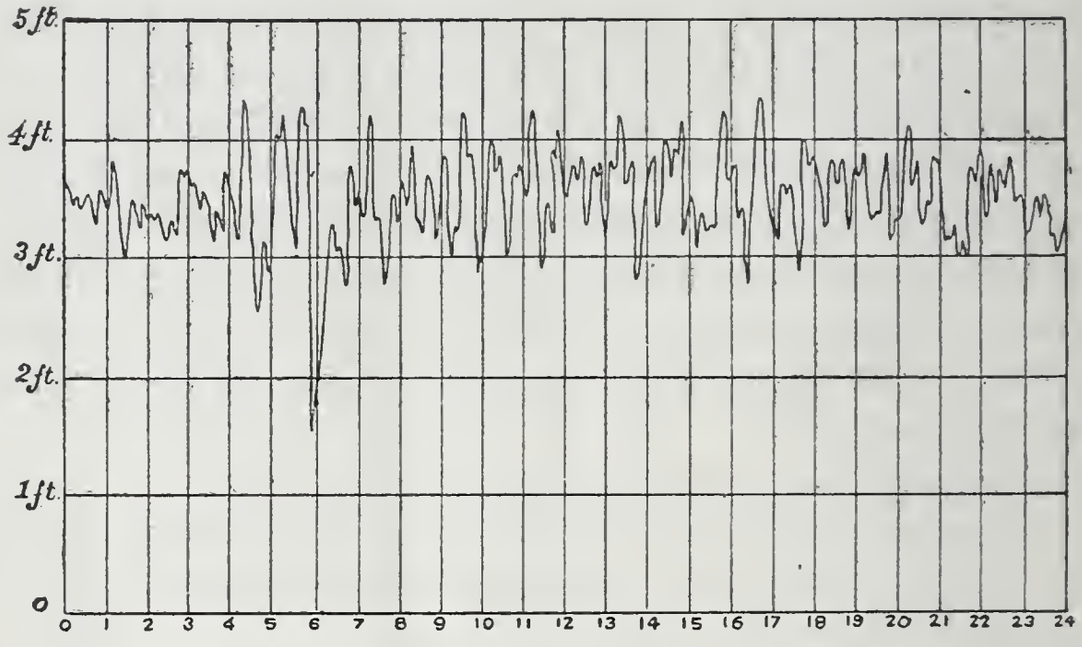
2. After collecting the sewage at some point south of the city, it can be pumped to some sandy areas about twenty miles distant, and there purified by irrigation or filtration of land.

3. A larger and deeper channel can be excavated to replace the present Illinois and Michigan Canal, which would carry enough water to sufficiently dilute the sewage of the future city, and discharge it into the Illinois River.

In order to determine the feasibility of discharging the sewage into Lake Michigan in a manner which would not pollute the water supply, a hydrographic study was made of the same, revealing a number of interesting facts, such as these:

The winds and barometric pressure produce a constant oscillation of the surface, and at times a swinging motion from shore to shore. The following diagram is a copy of the record of the automatic gauge which I had placed at the mouth of the Chicago River. One oscillation is distinctly recognizable as lasting about twenty minutes, which is the swing across the lake. The greatest of these, as will be seen, was over two feet. The oscillations are relatively greatest at the south end of the lake. Several spar buoys were anchored at suitable points, and their inclination and direc-

FLUCTUATIONS OF THE WATER SUPPLY OF LAKE MICHIGAN, AS RECORDED BY AN AUTOMATIC GAUGE, CHICAGO, ILL., *August* 16*th*, 1886.



At 7 A.M., area of Low Bar. passed over Lake Michigan eastwardly at the rate of 55 miles per hour. At 3 P.M. it was central at Buffalo. The wind at Chicago was from N.W. in the morning, shifting to S.W. in the afternoon.

tion were daily observed to show the current at such points. A number of trips were made across the lake, which is 60 miles wide at Chicago, to observe the currents in deep water, that is, in 25 to 50 fathoms. It is found that the wind is the prime factor in moving the water, and that the currents are generally in the direction of the wind. During a prolonged gale from the north it happens that perhaps the entire surface moves southerly, with the bottom current returning to the north. If the wind should change to the west, the surface current would then turn to about

northeast, forming a resultant between the wind and the bottom current until equilibrium takes place. West winds usually lower Lake Michigan and raise Lake Huron several inches, and east winds *vice versa*, causing strong currents in the Mackinaw Straits during the time. The motion of the water in the lake opposite Chicago is sometimes not inconsiderable. Currents of one to two feet per second are common.

The investigation of the scheme that contemplates a sewage disposal on land develops some formidable figures. The future population is assumed for the present inquiry as 2,500,000, and the water supply per day is taken at 350,000,000, gallons. If the same amount of water is turned upon one acre of land, as is customary in England, the necessary area for Chicago would reach over eighty square miles. If, instead of broad irrigation, intermittent filtration be made the basis of the disposal, the area is reduced to some twenty square miles. The soil for this purpose must be sandy, thus limiting the available territory to certain strips of land lying about twenty miles south of Chicago and extending into the State of Indiana. Cabbages and celery are the most profitable crops that can be raised on sewage farms. Therefore, besides supplying the country with meat from its gigantic slaughter houses, which, with the cattle sheds and other appendages, occupy about one square mile, Chicago might then, from its farm of about twelve thousand acres, supply a good share of the country's demand for these vegetables.

The third scheme, by which the sewage would be turned into the Illinois River, means practically to re-establish the ancient southern outlet of Lake Michigan, and to pour its waters again into the Mississippi River, where they went, geologically speaking, not long ago. The old bed of the outlet stream is quite marked. On much of its rocky bed scarcely two inches of soil have been able to form, and the shores of the ancient river stand for many miles as though they were still ready to again guide the stream. About eight miles of limestone rock forms the barrier which prevented the water from wearing down the channel and discharging into the Mississippi at this day. The softer rock of the St. Clair River gave way quicker, and lowered Lakes Huron and Michigan, so that the old southern outlet of the latter is now high and dry.

About ten miles west of Chicago the Desplaines River descends from the north, having a watershed of over eight hundred square miles, and discharging into this old outlet of the lake at a place called Summit, divides its water. A part flows eastward into the Chicago River and the lake, and a part flows westward, keeping the same name of the river above, until, when joining the Kankakee, it forms the Illinois River. The peculiarity of this topography which causes a river to split, sending a part of its water into the Gulf of Mexico and a part into the Gulf of St. Lawrence, is matched by the peculiarity of the river bed itself, which in summer is practically dammed up by grass and vegetation *west* of the summit, so that sometimes all of the water goes into the Chicago River, and which in winter, on account of ice dams *east* of the summit, discharges most of its water westward into the Illinois River. This and a number of other points bring many difficulties into the problem.

A channel which would so dilute the sewage that no offensive condition could occur, requires a capacity of probably 10,000 cubic feet per sec., in other words, to be about the size of the Chicago River. It would have to be excavated for over twenty-eight miles, eight of which are in rock. The flood waters of the Desplaines River must be provided for, either by an enlargement of its channel or by an interception and separate discharge into the lake north of the city. A double bifurcation of the Chicago River complicates the problem of constant circulation, which is a first condition if sewage is discharged into them. And numerous minor difficulties arise in carrying out this scheme.

On the other hand great benefits would appear, independent of the question of sewage disposal. A national advantage would be secured by the establishment of a large waterway between the Mississippi River and the lakes, to be used for commercial and military purposes. The descent of so large a body of water, having a constant quantity throughout the year, establishing a water power equal to perhaps one hundred thousand horse-power, would greatly aid in developing the manufactures of the State.

If the sewage of Chicago is absolutely prevented from discharging into the lake, the water supply question becomes comparatively simple. The water may be drawn from any point along the

city front with perfect impunity. Such an advantage, together with the comparative flatness of the area to be supplied, and the facility of driving tunnels through the clay underlying the city and the lake, allow of an unusually economical distribution. The area could be divided into districts of almost uniform size, each having a pumping station and a tunnel, and calculation will readily determine the most economical size of such an area for a given water consumption per head of population, a treatment which few, if any other cities, could receive, from the absence of the above peculiar advantages.

The whole investigation will be completed next summer.

XIII.

THE GRANITE QUARRIES OF CHESTER COUNTY, PENNA.

By J. H. Harden, Active Member of the Club.

Read December 18th, 1886.

Chester County has become noted for its granite (syenite), and recently three separate companies have been organized for the development of quarries in Warwick Township, on the line of the St. Peter's Branch of the Wilmington and Northern R. R., 40 miles direct and 60 miles by rail from Philadelphia.

An examination of the country from Springfield, on the northwest boundary of the county, to and beyond the Falls of French Creek, near Pughtown, a distance of more than six miles, discloses large boulders of syenite, scattered over a wide extent of surface, culminating at certain points in boulders of huge dimensions with the appearance of the solid "ledge" (outcrop) from which they were derived. Between Springfield and Joanna the same ledge of rocks appear in the railroad (W. & N.) cutting, and the St. Peter's Branch to the iron mines at Warwick and French Creek traverses a line parallel to the outcrop.

Adjacent to Warwick village and the ore mine of the same name, we find the Foxhill Granite Company opening a quarry. At the time of my visit (October) there were 40 men engaged

cutting up the boulders that lie scattered over the surface in all directions, requiring only plug and feathers to split them to shape and size, developing a beautiful gray syenite, fine in grain, uniform in color, free from iron or mica, and splitting equally well in any direction. A siding of a few hundred feet in length has been built into the quarry where we find the ledge has been developed, although at the present and for some time to come there are enough boulders to give employment for a strong force of men.

About one mile northeast we come to the Pennsylvania Granite Company's lands, 100 acres in extent, connected with the same branch railroad. Here we find 100 men at work cutting dimension stone and paving blocks from the boulders so profusely scattered over the property, and the parent ledge has been finely developed in several places, giving every evidence of excellent stone whenever it becomes necessary to quarry it.

Half a mile further to the northeast we come to St. Peter's Station, the terminus of the railroad, the iron ore mine, the Falls of French Creek and the French Creek Granite Company's works. The place has some local reputation as a summer resort, an hotel stands in the gap formed by the north branch of French Creek where it cuts through the granite outcrop. On the rising ground in front of the hotel are some of the very largest boulders to be found in the district. These are now being cut up by the Granite Company, who employ about one hundred men on work of a similar character to that last described. The photographs shown were taken by my brother (E. B. Harden), many of them before any work had been done at the quarry. No. II shows the face of the quarry a few months after beginning work.

At any of these quarries there should be no difficulty in obtaining the largest sized stone required for architectural purposes, equal to the old established quarries.

Regarding the quality of this granite, Dr. Charles M. Cresson, who has examined and reported (No. 4,740) thereon, says as follows:

"The samples of this granite consisted of a number of specimens of rough, undressed stone, and of a bar, and of several cubes for ascertaining the resistance of the stone to crushing strains, also of a specimen of polished stone.

This stone is a syenite of fine and even texture, the component quartz being less in amount and in much smaller masses than in the Quincy granite.

The so called Quincy granite (with which I have been directed to compare the French Creek stone) is also a syenite. I find that the Quincy granite weighs about 167 pounds, and the French Creek about 191 pounds to the cubic foot.

In the "New American Cyclopædia" (Appleton) it is stated that "there is a granite on Staten Island which has been largely used in New York for paving, which is remarkable for its extreme density, a cubic foot weighing over 180 pounds." "This difference would give the Staten Island Rock a decided advantage in the construction of submarine works, like break-waters, requiring great stability."

From this statement it is evident, therefore, so far as weight is concerned, the French Creek stone has an advantage over the superior Staten Island stone for submarine works.

In consequence of the finer grain the French Creek stone, in addition to greater density, also possesses greater toughness and resistance to wear than the Quincy stone, and experimental trials confirm this opinion.

Mr. John C. Trautwine, in his tables on the strength of materials, gives the ultimate average crushing load for granites and syenites at 300 to 1200 tons per square foot. Trials upon somewhat imperfectly prepared cubes of the French Creek stone showed that a force of over 23,700 pounds on each square inch, or over 1500 tons on each square foot, was necessary to crush them. With cubes carefully prepared with parallel sides and plane surfaces a much greater force would have been required for the purpose.

Experimental trials by chemical means of the ability of this stone to resist atmospheric influences calculated to produce disintegration, show that the French Creek stone is at least fully equal to the Quincy granite in that respect.

In my opinion the French Creek stone is a tougher, stronger and more durable stone than the Quincy granite, and better adapted for building or paving, or any other purposes to which the Quincy granite is applicable."

No better evidence of the value of Chester County granite should be required.

At all three quarries, and particularly at that of the French Creek Granite Company, there is a large quantity of waste stone that would make excellent material for macadamizing roads. The Foxhill and Pennsylvania Companies owning their quarries are working all they can get from a given amount of rough boulders; while the French Creek Company, working on a royalty, are less careful, casting stone that does not cut to the best advantage to the waste dump.

While there are only three organized companies, there are yet many favorable locations for opening other quarries, and we should not be surprised to find Chester County supplying all the paving blocks and a good part of the cut granite required in the City of Philadelphia and neighboring towns.

These rocks (specimens shown) I have reason to believe are not confined to Chester County. On the maps of the Second Geological Survey of Pennsylvania they are designated "trap," and some practical men have denied the correctness of the term.

Other samples, believed to have had the same origin but different in composition, accompany these notes.

XIV.

STAND PIPES.

By A. H. Howland, Active Member of the Club.

Read December 18th, 1886.

There have been several failures of stand-pipes in the last year, but the reasons for such failures are easily traceable, and have been found either in poor materials, workmanship, or both, or in faulty design.

The best form for stand-pipes is that of a perfect cylinder, as it presents the best form to utilize the strength of the metal and resist both internal and external pressures.

As the object to be attained, in using most stand-pipes, is to secure the largest possible amount of water at such an elevation as will make it available, the lower parts of stand-pipes are usually of but little use, and in some sections of the country it has been found cheaper to place a tank on an elevated structure of stone, brick, iron or wood.

The exact height at which it is best to stop the supporting structure and commence the tank depends entirely on the cost of the particular form of structure in the location desired. I have found it cheaper in some instances to build my iron cylinder from the ground, and in others to substitute some supporting structure.

The thickness of material used in the sides of stand-pipes varies with the proportions of the pipe and the quality of material to be obtained, and can always be determined by the following formula:

$$\frac{R \times H}{S \times P} \times F = T$$

in which,

R=radius, in inches.
H=height reduced to pounds pressure.
T=thickness.
S=theoretical tensile strength of material.
P=per cent. of strength of whole sheet in riveted joint.
F=factor of safety.

The latter three members are dependent on the first two and the material available.

It is now possible to obtain material (iron is best as being most uniform) having a tensile strength of 50,000 pounds per square inch of section.

By recent experiments made by the United States Government, it has been determined that properly proportioned double riveted seams possess 75 per cent. of the strength of the solid sheet, and single riveted ones 66 per cent. These figures can be taken as the values of P in these two cases.

The factor of safety to be used depends upon proportions and situation.

A pipe of large diameter and exposed position should have a larger factor than one of smaller diameter and in a protected location.

It is never safe to use a less factor than 3, and I have adopted 4 as a standard one for my practice.

Under these conditions, according to the formula, a stand-pipe 25 feet in diameter and 100 feet high should have a thickness of 0.694 inches at the bottom, and gradually decrease towards the top.

To follow out the formula, literally, for stand-pipes of small height, the theoretical thickness would be reduced below practical limits; I have, therefore, prepared the following tables, in which the first column gives the diameter in feet; the second, the capacity in U. S. gallons per foot in depth; the third, the minimum thickness for the top of the stand-pipe; the fourth, the distance from the top it is safe to carry the minimum thickness; the fifth, the distance from the top that it is safe to single rivet the vertical seams; and sixth, the thickness to add to the minimum for each additional five feet below the point given in column four.

It is feasible to obtain sheets that will "build" five feet each, and I have so assumed in these tables.

The decimals of an inch can be transferred into the nearest vulgar fractions, or wire gauge, by the use of the tables.

Many mills are now rolling sheets by decimals rather than any other standard.

Stand Pipes.

Tensile Strength of Material, 50,000 *lbs. per square inch. Horizontal Seams Single Riveted. Vertical Seams both Single and Double Riveted. Double Riveted Seams,* 75 *per cent. as strong as the whole sheet. Single Riveted Seams,* 66 *per cent. as strong. Factor of Safety,* 4. *Each Sheet to build* 5 *ft.*

Diam. Feet.	Gallons per foot in depth.	Minimum thickness for top. Inches.	Distance from top to carry minimum thickness. Feet.	Distance from top to carry single rivets. Feet.	Constant to add to minimum thickness for each 5 ft. below dist. given in 5th column. Inches.
5	147.0	0.1455	105	65	.0069
6	211.5	0.1494	90	55	.0083
7	287.9	0.1455	75	50	.0097
8	376.0	0.1554	70	45	.0111
9	475.9	0.1500	60	40	.0125
10	587.5	0.1525	55	35	.0139
12	846.1	0.1670	50	30	.0167
14	1,151.5	0.1940	50	30	.0194
15	1,325.9	0.2080	50	30	.0208
16	1,504.0	0.1989	45	25	.0221
18	1,903.6	0.2192	40	25	.0249
20	2,350.0	0.2218	40	25	.0277
22	2,843.5	0.2440	40	25	.0305
25	3,672.0	0.2425	35	20	.0347
27½	4,442.7	0.2681	35	20	.0383
30	5,304.0	0.2496	30	20	.0418
33	6,398,2	0.2754	30	20	.0459
35	7,197.0	0.2917	30	15	.0486
40	9,400.0	0.3332	30	15	.0555
45	11,897.0	0.3127	25	10	.0625
50	14,688.0	0.3465	25	10	.0693

The minimum top thicknesses do not increase uniformly with the diameters, as the arbitrary width of 5 feet in the sheets brings

the practical point of change first above and then below the theoretical point.

From the foregoing table the details of any stand-pipe can be readily determined and tabulated, as follows:

DETAILS OF STAND-PIPE, 25 FEET IN DIAMETER, 100 FEET IN HEIGHT.

Number of sheet.	Distance from top of stand-pipe to bottom of sheet. FEET.	Thickness of each sheet. INCHES.	Capacity from top of stand-pipe to bottom of each sheet. GALLONS.
1	5	0.2425	18,360
2	10	0.2425	36,720
3	15	0.2425	55,080
4	20	0.2425	73,440
5	25	0.2425	91,800
6	30	0.2425	101,160
7	35	0.2425	128,520
8	40	0.2772	146,880
9	45	0.3119	165,240
10	50	0.3466	183,600
11	55	0.3813	201,960
12	60	0.4160	220,320
13	65	0.4507	238,680
14	70	0.4854	257,040
15	75	0.5201	275,400
16	80	0.5548	293,760
17	85	0.5895	312,120
18	90	0.6242	330,480
19	95	0.6589	348,840
20	100	0.6936	367,200

× Single. Double Rivet Vertical Seams.

Weight can be obtained as follows:—Figure the superficial area of the stand-pipe of given diameter for five feet in height, multiply this by the weight of a square foot of metal of the thickness of each ring, add them all together and to the weight of the bottom, and then add 10 per cent. for laps and rivets; this being an average amount for this class of work. The result will be the weight of the whole, and the cost can be approximated by multiplying this weight by six cents, as an average price per pound for such work at the present time.

At the Fifteenth Annual Convention of the Master Mechanics'

Association, held at International Hotel, Niagara Falls, June 20th to 24th, 1882, Mr. R. H. Briggs, Master Mechanic of the M. & O. Railroad, reported for the Committee on Standard Wire Gauge that it was their opinion that all fixed gauges and numbers should *be abandoned,* and the Micrometer Sheet Metal Gauge substituted as the Master Mechanics' Standard Wire Gauge.

By the use of this gauge thousandths of an inch, or less, can be accurately measured; they are simple, durable and easily used.

The report was unanimously adopted, and hereafter the Master Mechanics will order all wire, sheet metals, etc., by known thicknesses of fractions of an inch, instead of the old numbers of "Wire Gauges."

As the bottom, when properly supported by the foundation, is subjected to none but compressive strains, its thickness need be no greater than can be thoroughly riveted and caulked, and, in case of small diameters, need not exceed one-eighth of an inch, while one-quarter of an inch is sufficient for the largest diameter. In joining the bottom to the sides I prefer to have the bottom extend outside of the sides and be joined thereto with an angle iron, placed on the outside, and double riveted to both the sides and bottom, as shown in the accompanying drawing, Fig. 1. This form adds some stability to the structure and brings both the edges of the angle iron outside where they can be readily caulked, to stop any leaks that there may be. The only objection to this form is, that it does not prevent the percolation of the water into the seam between the plates and around the rivets; but this should be guarded against by the plentiful use of cement and paint on the inside.

In riveting the sides it is best to have each ring conical, so that the upper edge, which is the most natural one to caulk, shall come on the inside of the stand-pipe, and thus prevent the water getting at the inside of the seam.

In stand-pipes of any size the joints should be thoroughly chipped and caulked with proper setts. Split caulking, as it is called, is not suitable, or to be depended upon except on small light work. Rivets should be large and thoroughly headed down; what is commonly called "knock down" riveting not being sufficient except for very small work.

The foundations of stand-pipes should, of course, be proportioned to the size and the nature of the material on which they rest; care being exercised not to overload the same. They should be of sufficient height to keep the bottom side plates above the surface of the ground, so that they can be easily got at to paint and caulk in case of leaks.

The top of the foundation should be level, and, when the bottom of the stand-pipe is lowered on to it, covered with some plastic substance, hydraulic cement or asphaltum being the best, so as to insure a perfect contact between itself and the bottom. After being lowered into place the upper edges of the seams of the bottom of the stand-pipe should be thoroughly caulked, as they are liable to be strained and opened in the process of lowering. To prevent rust, both the outer and inner surfaces of the stand-pipe should be thoroughly coated with red lead and afterwards with asphaltum, mineral or lead paint, as taste or circumstances may determine, and this paint should be renewed frequently, in order to prevent the commencement of any deleterious action.

Stand-pipes of small diameters and extreme height will need to be guyed, and sometimes anchored, to prevent overturning in case of high wind. It is not safe to build any stand-pipe, and not guy or otherwise secure it, that will not resist, when empty, the effect of a wind having a velocity of 50 miles per hour. Of course we are liable to have in all parts of the country winds of higher velocity than this, but when the stand-pipe is filled with water it will have much greater stability and the chances of its overthrow are not so many.

I append a table of velocities and pressures of wind to aid in calculating the resistance of any given stand-pipe. Theoretically, it will be necessary to calculate the centre of stability due to the varying thicknesses of the plates between the top and the bottom, but, practically, it will be sufficient to call the centre of both pressure and stability the centre of the vertical central section of the structure, and the effect of the pressure upon the cylinder as upon 9-16 of this central vertical section.

TABLE OF WIND VELOCITIES AND PRESSURES.

Velocity in miles per hour.	Velocity in feet per second.	Pressure in pounds per square foot.
1	1.467	.005
2	2.933	.020
3	4.400	.045
4	5.867	.080
5	7.33	.125
10	14.17	.500
12½	18.33	.781
15	22.00	1.125
20	29.33	2.000
25	36.67	3.125
30	44.00	4.50
40	58.67	8.00
50	73.33	12.50
60	88.00	18.00
80	117.30	32.00
100	146.70	50.00

XV.

CONTROLLING EXPANSION IN LOCOMOTIVES.

By W. E. HALL, Active Member of the Club.

Read January 22d, 1887.

IT is rather strange that more attention has not been given in locomotive practice to the means employed for adjusting the point of cut-off of steam in the cylinder. The nature of the requirements of the machine in this case are much different from those of stationary engines, where with the latter a governor can be used to maintain a constant speed irrespective of whatever variations may take place in the load. With locomotives, however, they must not only be able to start but should haul heavy loads against varying resistances and at various speeds, all with the minimum consumption of steam and, as a consequence, fuel.

With stationary engines constant speed is obtained in two ways, both of which are automatic. The one is where the variation in the load is accommodated by changing the point of cut-off of the steam, and, therefore, the grade of expansion, while the initial pressure remains constant. In the other case, a constant cut-off is retained for all loads, but the initial pressure is varied by throttling the steam before it enters the cylinder. In locomotive work, the engine is adjusted for full gear, ratio of expansion about 1.2, until the train is well started, when the engine is gradually cut back; that is, the cut-off earlier and expansion increased until the desired point for load, speed and resistance is obtained.

The mechanical combination at present used on locomotives for the purpose of varying the grade of expansion, consisting of a rack, reverse lever and catch, and with which most of you are more or less familiar, does not admit of a sufficiently close adjustment in the point of cut-off which necessitates throttling the steam more or less to obtain the proper working pressure. The use of higher steam pressures when and where practicable is becoming more extended, and the economy resulting therefrom is now unquestioned. In stationary engines with the proper proportions for the work required, it will be noticed that with governors used to throttle the steam a reduction in the initial pressure and a lower grade of expansion results, which is at once equivalent to a lower boiler pressure, while with governors controlling the speed by the cut-off, the maximum boiler pressure is utilized and the steam expanded to the best advantage. The same holds good with locomotives; when the cut-off cannot be properly adjusted by the reverse lever the throttle is brought into play, by which the initial pressure is reduced and a consequent reduction in economic performance.

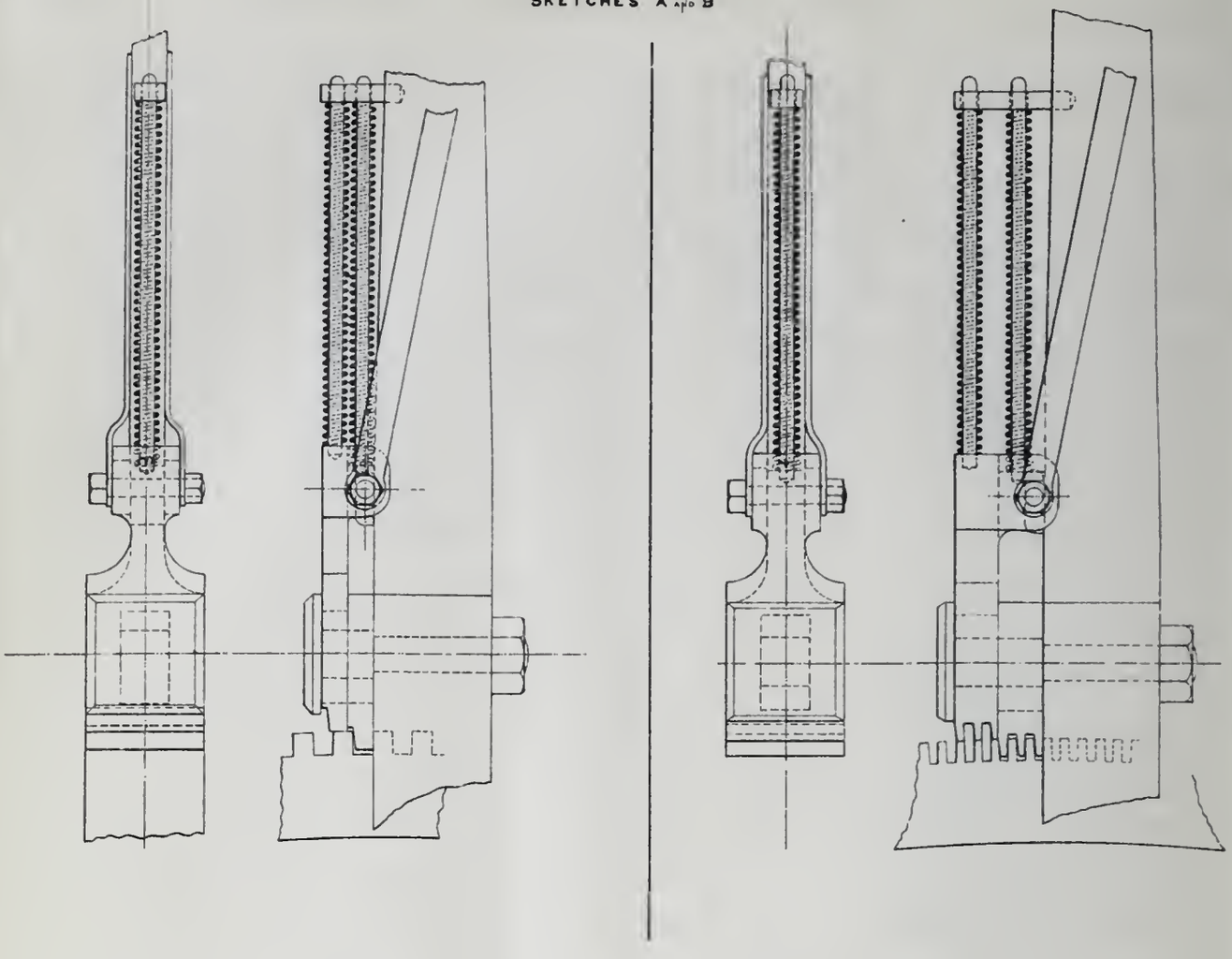
It should be noted that when the cut-off cannot be properly adjusted two losses arise; one from a reduction of initial pressure, and the second, the lower grade of expansion of steam by the longer admission.

Referring again to the form of reversing lever and rack as at present used on locomotives. As the proportions of lever and other parts of the combination do not differ much in American

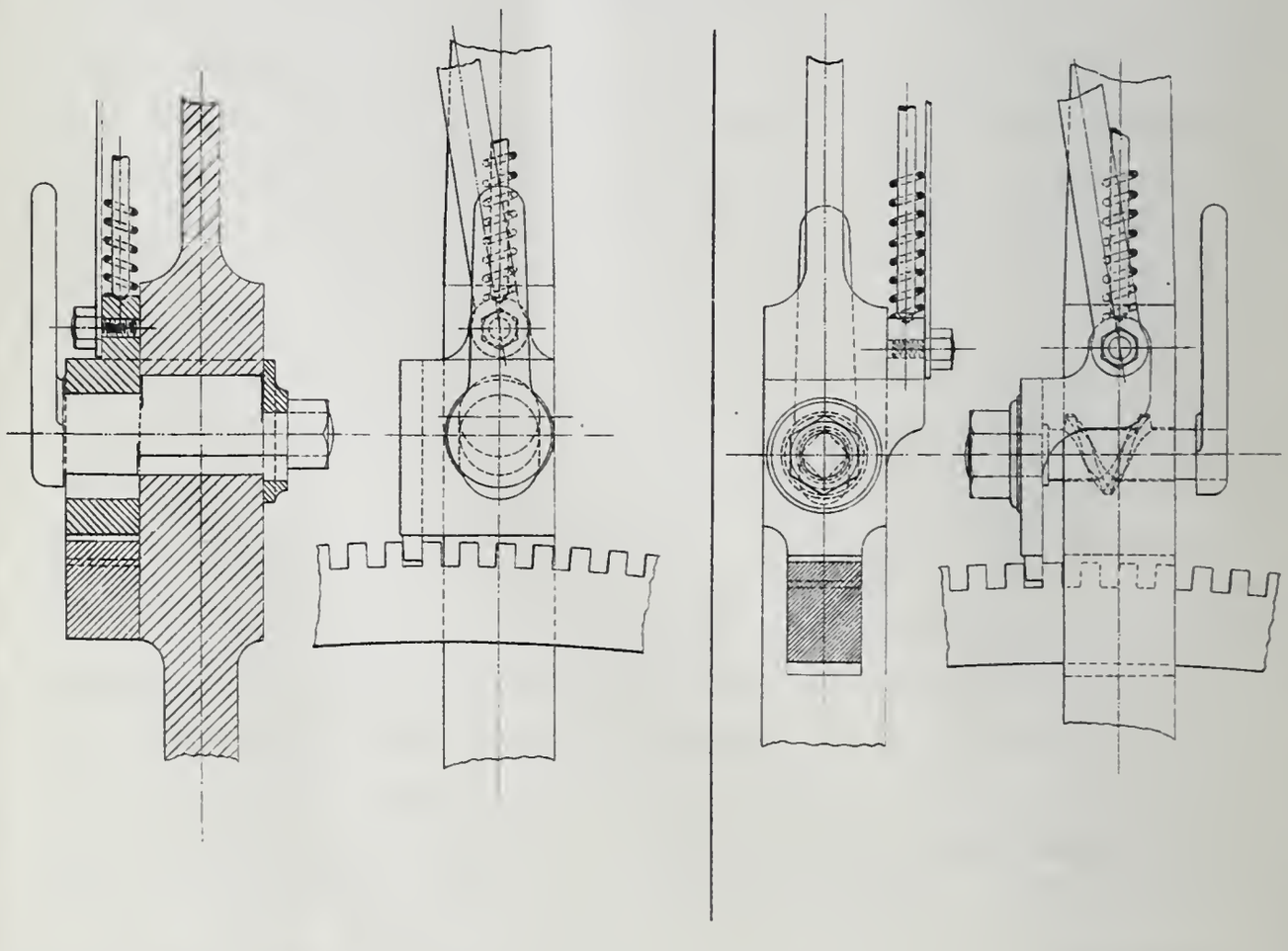
practice, the figures which follow, taken from a passenger locomotive, will be more or less of a general nature.

It has been found necessary for strength, when using a catch with single tooth, to make the teeth of the rack not less than three-eighths of an inch thick, which, assuming space between notches equal to width of a notch, allows a minimum adjustment at arc of three-fourths of an inch. In the engine taken this would correspond to a difference in point of cut-off, at a position of reverse lever where the engines are generally worked, of some two and one-half inches. When the work required of the engine corresponds to a grade of expansion which falls between two notches —or two such corresponding positions of the reverse lever—it is necessary to use the stronger one, and to throttle the steam to a point that the mean pressure will be sufficient to meet the work to be done by the engine. For example, let us suppose the case of load, speed, etc., to be such that with full boiler pressure of 140 pounds per square inch, the cut-off for best working would be at $10\frac{1}{4}$ inches, but that the closest heavier notch would cut-off at 12 inches. This would require throttling the initial pressure from 140 to 134 pounds, and their volumes at the respective pressures and cut-offs (20 inches diameter of cylinder) would be 0.5841 and 0.672 pounds of steam, and the total heat units to convert these quantities into steam of these pressures from 32° Fahr. would be 694.82 and 808.82 respectively. The same amount of work would be done in each case, as the mean pressure is the same, but a difference of 114 heat units, or a theoretical saving of 14 per cent., would result from the use of the higher initial pressure, earlier cut-off and consequent higher grade of expansion. This figure is somewhat higher than should be expected in practice, as the percentage condensation for relative volumes during admission would be greater with the earlier cut-off, together with other reasons of a practical nature. There is sufficient to show, however, that considerable economy would result if the work done by the engine could be wholly controlled by the ratio of expansion, the maximum attainable or the approximate boiler pressure being used for all grades of the same. In locomotive engines the proportions and requirements are such that the highest grade of expansion used does not pass the economic point, so that we have no reason to fear our going too far in this direction.

SKETCHES A AND B



SKETCHES C AND D



Burk & McFetridge Lith. Philad.a

Briefly, the condition of this subject is about as follows:—The early and present English practice has been to use a reverse lever with rack. The number of teeth in the latter was somewhat limited at first, but increased as the advantages to be derived thereby became known. The American practice at present is about the same as the English. The minimum thickness of teeth in the rack for requisite strength has been found to be three-eighths of an inch, which, as already stated, gives a minimum adjustment of lever at rack of three-fourths of an inch, causing a variation in point of cut-off of two and one-half inches at the position where it is most desired the engine should be closely worked. Recently this matter was agitated and many forms of steam and hydraulic reversing gear were designed and constructed. Their introduction was not at all general, but, on the contrary, rather limited, until from several years' experience with them they are now considered unsatisfactory. The objections that have been raised to the power reversing gear are the first and maintenance cost, and another, which is even more serious, that a means of enabling the enginemen to know the general working condition of the distributing mechanism is taken away, and cases can be cited where damage has been done by the power reversing gear to the working parts of the link motion when resistance existed therein, and which would have been prevented by the use of the lever form. It will also be noticed that there is less inducement for the engineman to keep the parts well oiled with the power than with the lever reversing contrivance, which affects materially the wear and the resistance of the mechanism. The rack has occasionally been replaced by a screw with a nut running on the latter, while the nut is connected with the reversing lever. With this arrangement any desired point of cut-off can be obtained, but the necessarily slow in action and clumsy construction which it requires has prevented its general use. The leverage is obtained by means of a large hand wheel attached to one end of the screw.

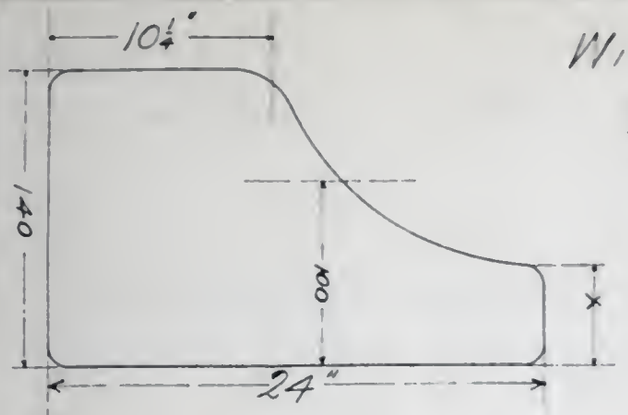
Some time ago a lever with double catch was designed by the writer, and constructed as shown in sketches *A* and *B*. In one case the number of teeth in the rack was increased, the thickness of which was reduced from three-eighths of an inch to three-six-

teenths of an inch, for the purpose of obtaining a finer adjustment. A trial showed that the finer teeth were not serviceable, and even the general design at its best only half accomplished the point desired, and was for this reason abandoned.

The construction shown in sketches *C* and *D* was then designed, and it will be seen that while retaining the desirable features of the present motion, such as rapidity in handling, etc., yet allows the lever to be placed in any of the possible positions within the range of the rack. The only important change is the bolt connecting the catch with the lever. This bolt is made movable, and upon part of its surface the principle of the inclined plane as applied—for example, in the form of an eccentric or screw—and by the motion of the bolt the relative position of catch and lever can be altered. It will, therefore, be readily seen that if the bolt is so constructed as to give a throw equal to the width of a notch and a space between them that the lever can be placed in any of the possible positions within the range of the rack. The location of the catch, whether at the side, in front of or passing through the lever, is simply a mattter of detail.

In considering this matter more fully we obtain the results shown in the comparative example which is given in detail on the accompanying lithograph.

The example taken gives a condition somewhat beyond what would be the average for, as mentioned, the variation in the cut-off with a difference in position of reverse lever of one notch corresponds, when lever is close to central position or cut-back, to some two and one-half inches. The average gain with a lever adjustable for any point would be one-half of this, or one and one-fourth inches. As the example taken was for a difference of one and three-fourths inches, we have an *average theoretical economy* of 10.57 per cent. We do not attempt to assert that the use of such a contrivance will decrease the coal bill this amount, but it is claimed that at times when the advantages to be derived from this construction are properly utilized, that a large part of the above figure will be obtained. The experience with the double latch verifies this assertion.



WITH THE CUT-OFF AT 10¼"

$$\frac{\pi d^2}{4} \cdot 10\tfrac{1}{4} : \frac{\pi d^2}{4} 24 = x : 140$$

$x = 59.8$ = FINAL PRESSURE

$100 \times 13\tfrac{3}{4} = 1375.00$

$140 \times 10\tfrac{1}{4} = 1435.00$

$2 \,\underline{)\, 2810.00}$

117 = MEAN PRESSURE

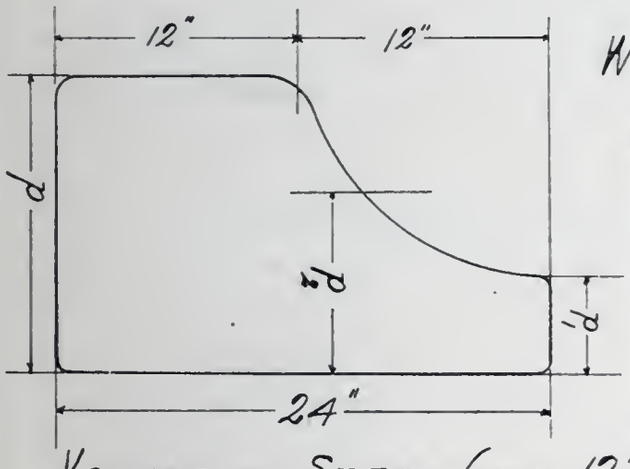
DIAM. OF CYLINDER = 20"

VOLUME OF STEAM = 3220.14 CU. INS. = 1.863 CU. FEET

ONE LB. OF STEAM AT 140 LBS. PRESSURE = 3.1896 CU. FEET

HENCE, VOLUME OF STEAM = 0.5841 LBS.

TOTAL HEAT REQUIRED TO GENERATE ONE LB. OF STEAM FROM WATER AT 32° FAHR. (CONSTANT PRESSURE 140 LBS.) = 1189.57 HEAT UNITS. 1189.57 × 0.5841 = 694.82 HEAT UNITS FOR ABOVE CUT-OFF.



WITH THE CUT-OFF AT 12"

WE HAVE $\frac{p}{p_1} = \frac{2}{1}$; $p_1 = \frac{1}{2} p$

$$\frac{p_1 + p}{2} = p_2 = \frac{p + \frac{1}{2}p}{2} = \frac{3}{4} p$$

$$\frac{3}{4} p \times 12 + p \times 12 = 2810 ; p = 133.8$$

VOLUME OF STEAM (FOR 12" ADMISSION) = 3769.92 CU. INS. OR 2.182 CU. FT.

ONE LB. OF STEAM AT 134 LBS. PRESSURE = 3.2452 CU. FT.

HENCE, VOLUME OF STEAM = 0.672 LBS.

TOTAL HEAT REQUIRED TO GENERATE ONE LB. OF STEAM FROM WATER AT 32° FAHR. (CONSTANT PRESSURE 134 LBS.) = 1188.72 HEAT UNITS. – 1188.72 × 0.672 = 808.82 HEAT UNITS FOR THIS CUT-OFF.

FOR THIS EXAMPLE THERE IS A DIFFERENCE OF 114 HEAT UNITS – OR A SAVING OF SOME 14 PER CENT.

Burk & McFetridge, Lith. Phila.

XVI.

CENTRIFUGAL PUMPS AT MARE ISLAND NAVY YARD, CALIFORNIA.*

By H. R. Cornelius, Active Member of the Club.

Read January 8th, 1887.

In December, 1883, bids were asked for by the United States Government on Pumping Machinery, to remove the water from a Dry Dock for vessels of large size.

The dimensions of the Dock, which is situated on San Pablo Bay, directly opposite the city of Vallejo, are as follows:

Five hundred and twenty-nine feet wide at its widest part, 36 feet deep, with a capacity at mean tide of 9,000,000 gallons.

After receiving the contract, several different sizes of pumps were considered, but the following dimensions were finally chosen: Two 42-inch Centrifugal Pumps, with runner 66 inches in diameter and discharge pipes 42 inches, each driven direct by a vertical engine with 28-inch diameter cylinder and 24-inch stroke.

These were completed and shipped in June, 1885, on nine cars, constituting a special train, which arrived safely at its destination in the short space of two weeks, and the pumps were there erected on foundations prepared by the Government.

From the "Report of the Chief of Bureau of Yards and Docks" I quote the following account of the official tests:

"The Board appointed to make the test resolved to fill the dock to about the level that would attain in actual service with a naval ship of second rate in the dock, and the tide at a stage which would give the minimum pumping necessary to free the dock. The level of the 20th altar was considered as the proper point, and the water was admitted through two of the gates of the caisson until this level was reached; they were then closed. The contents of the dock at this point is 5,963,921 gallons.

"The trial was commenced and continued to completion without any interruption in a very satisfactory manner.

"In the separate trials had of each pump the average discharge per minute was taken of the whole process, and there was a singular uniformity throughout with equal piston speed of the engine.

"It was to be expected, and in a measure realized, that during the first moments of

* Built by the Southwark Foundry and Machine Company, of Philadelphia.

the operations, when the level of the water in the dock was above the centre of the runner of the pumps, that the discharge would be proportioned to the work done, where no effort was necessary to maintain a free and full flow through the suction pipes, but as the level passed lower and farther away from the centre there was no apparent diminution of the flow, and no noticeable addition to the load imposed on the engine. The variation in piston speed, noted during the trial, was probably due to the variation of the boiler pressure, as it was difficult to preserve an equal pressure, as it rose in spite of great care, owing to the powerful draft and easy steaming qualities of the boilers.

"After the trial of the second pump had been completed the dock was again filled through the caisson, and as both pumps were to be tried, the water was admitted to a level with the 23d altar, containing 7,317,779 gallons, which was seven feet above the centre of the pumps; this was in favor of the pumps for the reasons before stated. In this case all the boilers were used.

"Everything moved most admirably, and the performance of these immense machines were almost startling. By watching the water in the dock it could be seen to lower bodily, and so rapidly that it could be detected by the eye without reference to any fixed point.

"The well which communicates with the suction tunnel was open, and the water would rise and fall, full of rapid swirls and eddies, though far above the entrance of these tunnels. Through the man-hole in the discharge culvert the issuance from the pipes could be seen, and its volume was beyond conception. It flowed rapidly through the culvert, and its outfall was a solid prism of water, the full size of the tunnel, projecting far into the river.

"During a pumping period of 55 minutes, the dock had been emptied from the twenty-third to two inches above the sixth altar, containing 6,210,698 gallons, an average throughout of 112,922 gallons per minute. At one time, when the revolutions were increased to 160 per minute, the discharge was 137,797 gallons per minute; this is almost a river, and is hardly conceivable. After the pumps were stopped, on this occasion, tests were made with each in succession as to the power of the ejectors with which each is fitted to recharge the pumps.

"The valves in the discharge pipe were closed and steam admitted to the ejector, the pump being still and no water in the gauge glass on the pump casing, which must be full before the pumps will work. The suction pipe of the ejector is only two and a-half inches in diameter, the steam pipe one inch in diameter. To fully charge the pumps at this point required filling the pump casing and the suction pipe containing about 2,000 gallons; this was accomplished in four minutes, and when the gauge glass was full the pump operated instantly and with certainty, discharging its full volume of water.

"I went on several occasions down in the valve-pits on the ladder of the casing, and to all accessible parts while in motion at its highest speed, and there was no undue vibration, only a uniform murmur of well-balanced parts, and the peculiar clash of water against the sides of the casing as its velocity was checked by the blank spaces in the runner.

"The pumps are noisy while at work, due to the clashing of the water just mentioned, but it affords a means of detecting any faulty arrangements of the runner or unequal discharge from any of its openings. While moving at a uniform speed, this

clashing has a tone whose pitch corresponds with that velocity of discharge, and if this tone is lacking in quality, or at all confused, there is want of equality of discharge through the various openings of the runner. To this part I gave close attention, and there was nothing that the ear could detect to indicate aught but the nicest adjustment. The bearings of the runners worked with great smoothness, and did not become at all heated. Through a simple, novel arrangement, these bearings are lubricated and kept cool. There is a constant circulation of water from the pumps by means of a small pipe, which completes a circuit to an annular in the bearings back to the discharge pipe while the pump is in motion, requiring no oil and making it seemingly impossible to heat these bearings.

"The large cast steel valves placed in the embouchement of the casing, it was thought, might act to check the free discharge, and arrangements were provided for raising and keeping them open by a long lever key attached to their axes of revolution, but to our great surprise the first gush from the pumps these valves, weighing nearly 1,500 pounds, were lifted into their recessed chambers, giving an unobstructed opening to the flow, and they floated on its surface unsupported, save by the swiftly flowing water, without a movement, while the pump was in operation.

"The steam-actuated valves in the suction and discharge pipes worked very well, and the water cushion gave a slow, uniform motion, and without shock, either in opening or closing them.

"The engines worked noiselessly, without shock or labor. At no time during the trial was the throttle valve open more than three-eighths of an inch.

"The indicator cards taken at various intervals gave 796 horse-power, and the revolutions did not exceed 160 at any time, though it was estimated that 900 horse-power and 210 revolutions would be necessary to attain the requisite delivery; so that there is a large reserve of power available at any time.

"The erection of this massive machinery has been admirably done. The parts, as sent from the shops of the contractor, have matched in all cases without interference here; and, when lowered into place, its final adjustment was then made without the use of chisel or file, and has never been touched since.

"The joints of the steam and water connections were perfect, and the method of concentrating all valves, waste pipes, and important movements at the post of the engineer in charge, gives him complete control of the whole system of each engine and pump without leaving his place, and reduces to a minimum the necessary attendance. All the parts are strong and of excellent design and workmanship; simple, and without ornamentation.

"Looking down upon them from a level of the pump-house gallery, they are impressive and massive in their simplicity.

"The Government is well worthy of congratulation in possessing the largest pumping machinery of this type and of the greatest capacity in the world, and the contractors have reason to be proud of their work."

XVII.

HYDRAULIC DREDGING MACHINES.

By Conway B. Hunt, Active Member of the Club.

Read January 22d, 1887.

It is proposed to refer briefly to one or two of the typical hydraulic dredging machines that have been devised lately, and to describe in detail an example that is at present in successful operation in this country. The principle of hydraulic dredging, that is, the mixing of dredged material with water and then removing it either by suction or otherwise, was applied to various machines constructed by English engineers as early as 1800. A form of dredge used at Chatham Dockyards had a telescopic up-cast pipe with a bell-shaped foot, beneath which revolved an excavating screw. A rotary pump created a partial vacuum in the pipe and the material as raised was deposited in lighters. This description is typical of most of the dredges since designed until very recent years, when the development of some novel details, mainly the results of American inventions, seems to promise a successful future for the machine. These details consist in the methods proposed for excavating the material, for mixing it uniformly with water and for raising and discharging the mixture.

The simplest class of hydraulic dredging machines is typified by the "Roy Stone" dredge, which depends upon the scouring and transporting action of a jet of water. A heavy stream from a powerful pump is directed through a flexible pipe against the bottom or bank to be removed, and rapidly disintegrates the material. The removal of the detritus may be left to tidal or current forces, or else a second jet of water may be directed into the lower end of an inclined excavating tube, carrying with it the material torn up by the first jet. The excavating tube may deliver into scows or otherwise.

There is another class of dredging machines which are characterized by the "bucket-wheel" principle on which their excavating apparatus is designed. An excellent example of them is the so-called "Bowers' Dredge," a machine of which much is promised.

It has a rotary excavator of a generally cylindrical shape, provided with radiating bottomless buckets, having sharp edges which cut into the material and deliver it, mixed with a certain proportion of water, through the buckets to the interior of the excavator, from which it is removed by suction. The general method of hydraulic transportation of the dredged material that is provided does not differ, save as to details, from that of the Von Schmidt system, which is about to be described in detail. Although there is at present no example of the Bowers' dredge in existence, yet it would seem that the principles embodied in its general design are those from which excellent practical results may be expected.

The Von Schmidt system of hydraulic dredging has stood the test of actual work, and is at present in successful operation in two localities in this country. Two of this class of dredges are at present engaged on the improvement of the Potomac River, at Washington, D. C., a work of large proportions that is being carried out by the United States Government, on the general plan of deepening the channel by dredging and raising the bank on the city front by depositing the dredged material thereon. Each of these dredges is 100 feet long and 50 feet wide and contains two engines, one to run the centrifugal pump and a small auxiliary one to work the excavator, raise and shift the suction pipe, move the dredges, etc. The bow of the dredge is a semicircle in plan, to the centre of which is pivoted a sector-shaped table of about 60 degrees central angle. This table travels around the bow of the boat from side to side and carries the suction pipe, the shaft and gearing of the excavating apparatus, and the posts, stays, etc., necessary to give all these a steady vertical position. At the foot of the suction pipe, somewhat eccentric therefrom, there is a conical sheet-iron bonnet, eight feet in diameter and about 18 inches pitch, beneath which revolves the plow for loosening the material. This plow consists of a horizontal circular iron frame or ring, attached by radial arms to the vertical driving shaft which runs up the side of the suction pipe. To this frame are attached the plows proper, which are simply heavy knives about two feet in length, secured in a vertical position, points downward. There are in addition

four heavy cutting knives fastened to the circular frame by plates that lap under the edge of the bonnet under which the plows work and then turn upward, so that these knives have a vertical position, points upward. The purpose of this peculiar arrangement is to cut away the material from the top of the bonnet when the excavating apparatus becomes by any means too deeply "engaged." The suction pipe is 22 inches in diameter and is telescopic, so as to accommodate its length to the various depths of water in which the dredge works. Its lower end is provided with a back-flow valve to enable the pipe to be filled with water from above, a necessary proceeding previous to starting the pump. The pump is a centrifugal one, of special design. The main chamber, in which the wings revolve in a vertical plane, is eight feet in diameter and 22 inches in width. Its lower half is jacketed by an outer chamber through which the material is taken from the suction pipe at the rim, and admitted to the pump at the centre through openings in the sides of the main chamber. The shaft to which the wings are attached is surrounded by a water packing at its entrance to the pump chamber, to prevent any leaking of air at these bearings and consequent impairment of the vacuum. The wings are six in number, and their radial direction is deflected away from the direction of their revolution. The pump is geared directly to the engine, which is double, with cylinders 22 inches in diameter and 24-inch stroke. They are run at 130 revolutions per minute, with a steam pressure of 90 pounds at the boiler and cut off at one-half stroke, and their effective horse-power is rated at 200. The discharge pipe leads off at a tangent from the main chamber of the pumps, and, after leaving the dredge, is carried to the shore on pontoons and thence to the point of discharge along the surface of the ground. It is of sheet-iron, 20 inches in diameter, and made in 32-feet and 16-feet lengths, the longer being used on the portion resting on pontoons and the shorter ones on the shore section. The joint connections of the discharge pipe are of rubber hose, two and one-half feet long and slightly larger than the pipes, over the ends of which they fit tightly and are secured by iron straps.

The general operation of dredging is briefly as follows:—The

machine being secured in position by spuds, the suction pipe is lowered to the bottom to be dredged, and the plows and pump are started, the latter being first "primed." The table is then swung slowly around the bow of the boat, the plows cutting a nine-foot swathe, two feet deep, and the shape of a semi-circle 60 feet in diameter, all the spoils being carried away through the suction as fast as dredged. By shifting the position of the dredge or lowering the suction pipe, any desired size and depth of cut is obtained. The operator is guided in his management of the excavating apparatus by a vacuum gauge attached to the suction pipe, which serves as an index of the proportion of mud or other material which is entering the suction. As the plows become too deeply engaged, this gauge marks a more perfect vacuum, and the reverse indicates a contrary condition. The consequence of admitting too large a proportion of solid matter to the suction is the clogging of the discharge pipe by the deposit of the surplus in its depressions and joints. The percentage of solid matter, which it is found best to admit to the suction, varies greatly according to the nature of the material. In dredging mud as high as 40 per cent. has been averaged, while in sand the percentage is much less. The *efficiency* of the dredge in hard material is noticeable, but it is not an economical machine for this class of work, on account of the large amount of water that must be moved in order to carry the material through the pipes.

The record of three Von Schmidt dredges of about equal capacity during the year ending June 30th, 1886, and covering a working period equivalent to 26½ months of a single dredge, shows that the machinery was run for 8,725 hours, equivalent to 13.2 hours per day, or 55 per cent. of the available time. No work was done on Sundays, and two months during the winter, during which no operations were attempted, are omitted from the calculation. The remaining 45 per cent. of the available time was occupied in making repairs, in cleaning the pipes, in moving the dredges, etc., or were lost by reason of winds, currents, ice, etc. The total amount of material excavated and deposited on shore was 1,527,000 cubic yards, an average of 175 cubic yards per working hour, 2300 cubic yards per average working day of 13.2 hours, and equal to 4200 cubic yards per full day of 24 hours.

While these results are averages, covering long periods of time, they were frequently far surpassed. As much as 400 yards per hour has been dredged, and 300 is frequently exceeded and the rate maintained for a number of hours. Eight thousand cubic yards in 22 hours is about the best day's work recorded. It is to be noted that these quantities are all derived from cross-sections of the river-bed before and after dredging, and are consequently only about 75 per cent. of what the same material would amount to if measured in scows. The material was deposited on shore through pipe varying from 500 to 3500 feet in length, the average distance being about 1500 feet, and at a height of discharge of from six to ten feet above the water level. The work was done under contract at prices of 12.37 cents, 15 cents and 15.45 cents per cubic yard. The final estimates were specified to be made by cross-sections of the completed fill after it had become solidified and compacted. Before any material was deposited, a section of the river flats was inclosed by an embankment or levee about eight feet high. This work was done by means of dipper dredges or their equivalent, and within this inclosed space the semi-fluid spoils from the hydraulic dredges were discharged, suitable drains and sluices being provided for carrying off the water. Where the material to be dredged from the river was too far removed from the place of deposit to be conveniently reached by the hydraulic process, dipper dredges were employed to dredge it into scows, which were towed to and unloaded in front of the hydraulic machines, and the material was then redredged by them and put ashore. These facts are to be considered in connection with the prices named above, which included all such items. The Von Schmidt dredge is not yet perfected, and it is believed that its efficiency can be greatly increased. The low price at which it can profitably do dredging of the general class embraced in River and Harbor improvements, and the satisfactory condition as to grade in which the cut and fill are left, are strong points in favor of the machine.

It may be noted, in conclusion, that the general requirements of a successful hydraulic dredge would seem to be, first, such a plow system as will excavate and thoroughly mix with water the material to be dredged and deliver it uniformly to the suction;

second, a properly designed pump of sufficient power, presumably centrifugal, that will freely pass anything that can enter the suction, driven by an engine fully capable of developing the pumps best duty; and third, a general system of suction and discharge pipe which shall develop the least practicable frictional resistance, especially that due to bends. The numerous devices and details by which these requirements are attainable are, and necessarily will be, the subjects of various patents, and, as a consequence, their most efficient combination may be long deferred. The large number of machines that are still in the experimental stage of development would indicate that the best results attainable from hydraulic dredging machines have not as yet been accomplished.

APPROXIMATE METRIC EQUIVALENTS.

By Fred. Brooks, Civil Engineer Correspondent, June 19th, 1886.

This table shows the comparative size of the principal metric and old units, arranged so that approximate equivalents may easily be absorbed by the memory. Three leading units, of length, weight and bulk, are made conspicuous each as nine-tenths of its metric analogue; and the true relations among the old units are adhered to as far as practicable in the approximate equivalents, so that one equiva-

LENGTH.					AREA.		
1 inch	and	2½	centimeters	(2.54)	1 sq. inch	and	6¼ sq.
1 foot	"	0.3	of meter .	(.3048)	1 sq. foot	"	0.09 of
1 Yard	"	**0.9**	**" Meter** .	(.9144)	1 sq. yard	"	0.81 "
1 rod	"	5.	meters . .	(5.029)	1 sq. rod	"	25. sq.
1 chain	"	20.	" . .	(20.117)	1 rood	"	1000. "
1 furlong	"	200.	" . .	(201.17)	1 acre	"	0.4 of
1 mile	"	1600.	" . .	(1609.3)	1 sq. mile	"	256.

WEIGHT.							
					1 pound	and	0.45
					60 lbs. (wheat bu.)	"	27.
					80 lbs. (coal bu.)	"	36.
1 grain	and	.06¼	of gram	(.0648)	1 cental	"	45.
1 troy ounce	"	30.	grams	(31.103)	112 lbs. (cwt.)	"	50.
					1 Net Ton	"	**0.9**
1 avoir. "	"	27.	grams	(28.35)	1 gross ton	"	1.

COMBINATIONS.			
		1 foot-ton (net)	and
		1 foot-pound	"
		1 pound per running yard	"
		1 " " " foot	"
		1 pound per sq. foot	"
	(About 1 Atmosphere)	1 net ton " " "	"
		15 lbs. " " inch	"
		1 pound " " "	"
		1 net ton " " "	"
		1 pound per cu. foot	"

lent may be associated in the mind with another. For example, the quart being 0.9 of a cubic decimeter, the cubic foot, or 30 quarts, is 30 × 0.9, or 27 cubic decimeters; again, the ounce, or weight of $\frac{1}{1000}$ cubic foot of water, is the weight of 27 cubic centimeters of water, or 27 grams. The approximations that are grouped together generally contain the same percentage of inaccuracy. Values sufficiently accurate for business purposes are added in parentheses.

		BULK.				
centim's	(6.451)	1 cu. inch	and	$15\frac{5}{8}$	cu. centimeters	(16.387)
sq.meter	(.0929)	1 cu. foot	"	0.027	of cu. meter	(.028316)
"	(.8361)	1 cu. yard	"	0.729	" " "	(.7645)
		100 cu. feet	"	2.7	cu. meters . .	(2.8316)
meters	(25.29)	(The unit of ship's measurement for register.)				
"	(1011.7)	1 M board meas.	and	$2\frac{1}{4}$	cu. meters .	(2.36)
hektar	(.4047)					
hektars	(258.99)	1 cord	"	3.6	" " . .	(3.624)
of kilo	(.4536)	1 U. S. liq. pint	"	0.45	of liter . . .	(.473)
kilos	(27.216)	1 " " " **Quart**	"	**0.9**	" **Liter** . .	(.946)
"	(36.287)	1 " " " gallon	"	3.6	liters	(3.785)
"	(45.36)	1 peck	"	9.	"	(U.S. 8.81; Br. 9.08)
"	(50.8)	1 bushel	"	36.	"	(U.S. 35.24; Br. 36.35)
Met. Ton	(.9072)	1 ton of ship's displacement	"	1	cu. meter.	
"	(1.016)					

0.27	of (metric) ton-meter . . .	(.2765)	WEIGHT & LENGTH.
$0.13\frac{1}{2}$	" kilogrameter	(.13825)	
$\frac{1}{2}$	kilo per running meter . .	(.4961)	WEIGHT PER LENGTH.
$1\frac{1}{2}$	kilos " " " . .	(1.4882)	
5.	kilos per square meter . .	(4.883)	WEIGHT PER AREA.
1	kilo per sq. centimeter . .	(0.9765)	
1	" " " " . .	(1.0545)	
0.07	" " " " . .	(.07031)	
0.14	metric ton per sq. centimeter	(.14062)	
16.	kilos per cu. meter	(16.019)	WEIGHT PER BULK.

WEIGHTS OF CAST IRON WATER PIPES.

A. H. Howland, December 4th, 1886.

The following table shows the thicknesses, weights and strengths of such pipes as we have adopted for standard use, in ordinary cases. The smaller pipes are heavier than are, theoretically, necessary for most places, but in adopting a standard, one was taken that would be sufficient for the majority of places met with in practice.—A. H. Howland and George A. Ellis.

Internal Diam.	Thickness.	Weight per foot of cylinder.	Weight per foot of pipe, laid, including bells.	Weight per length of pipe to lay 12 feet.	Ultimate strength when made of iron having tensile strength of 18,000 lbs.	One-fifth of the ultimate strength.
Inches	Inches.	Lbs.	Lbs.	Lbs.	Lbs. per sq. inch.	Lbs. per sq. inch.
4	0.40	17.27	18.75	225	3600	720
6	0.42	26.46	28.92	347	2515	503
8	0.45	37.33	40.50	486	2025	405
10	0.50	51.54	56.17	673	1800	360
12	0.55	67.76	73.75	885	1650	330
14	0.58	83.02	90.67	1088	1490	298
16	0.60	97.78	106.78	1281	1350	270
18	0.64	117.11	126.67	1520	1280	256
20	0.70	142.25	153.43	1841	1260	252
24	0.80	194.77	210.33	2524	1200	240
30	0.90	273.00	285.33	3524	1080	216
36	1.00	363.22	390.50	4686	1000	200
40	1.10	443.82	480.83	5770	990	198
42	1.16	491.49	532.42	6389	995	199
48	1.30	629.16	681.58	8179	975	195

ANNUAL REPORT OF THE SECRETARY AND TREASURER,

For the Fiscal Year 1886.

Presented January 8th, 1887.

To the Officers and Members of the Engineers' Club of Philadelphia:

Gentlemen:—I have the honor to present the following statement of the receipts and expenditures for the fiscal year from January 9th, 1886, to January 7th, 1887, both inclusive.

Howard Murphy, Secretary and Treasurer, in account with
The Engineers' Club of Philadelphia.

Dr.

Balance on hand Jan. 8th, 1886,		$609 40
Initiation Fees, Active,	210 00	
" " Associate,	5 00	215 00
Dues, 1881, Resident,	6 50	
" 1882, "	50	
" 1883, Non-resident,	5 00	
" 1884, Resident,	7 50	
" " Non-Resident,	10 00	
" 1885, Resident,	67 50	
" " Non-resident,	29 52	
" 1886, Resident,	1391 25	
" " Non-resident,	505 00	
" " Associate,	37 50	
" 1887, Resident,	450 00	
" " Non-resident,	142 27	
" " Associate,	37 50	
" 1888, Resident,	50	2690 54
Sales of Proceedings, Authors,	47	
" " Members.	41 93	
" " Non-members,	12 00	54 40
Advertisements, 1882,	12 00	
" 1883,	12 00	
" 1884,	36 00	
" 1885,	195 00	
" 1886,	318 00	573 00
Key deposits,		1 50
Sundries,		38
		$4144 22

Cr.

Rent,		1000 00	
Gas,		41 44	
Coal-oil for Janitor,		5 20	
Coal, Small Stove,	100 95		
Egg,	42 75		
Chestnut,	5 50	149 20	
Janitor,		223 33	
Ice,		21 90	
House Expenses,		27 42	
Repairs,		2 32	
Christmas present,		5 00	1475 81
Salary, Secretary and Treasurer,		1000 00	
" Clerk,		43 33	1043 33
Proceedings, Vol. V., No. 3,		307 55	
" " " " 4,		210 83	
" " " " 5,		235 63	
" " VI., " 1, on account,		6 75	760 76
Reference Book,			9 75
List of Members,			80 03
Notices and Records of Meetings and Elections,			120 13
Miscellaneous Printing and Stationery,			85 77
Postage,			166 90
City Directories,			6 50
Messenger, telegraph and express service,			1 29
Key deposits returned,			2 75
Law suit expenses,			23 49
Sundries,			2 52
Balance, cash on hand, January 7th, 1887,			365 19
			$4144 22

The following are the closely approximate assets of the Club, in addition to its library and furniture:

Cash Balance Jan. 7th, 1887,	365 19
Due from Members to end of fiscal year 1886; initiation fees and dues,	613 38
Due for advertisements,	467 00
" Proceedings, etc.,	27 44
	$1473 01

The only liabilities of the Club are for the current quarter's gas bill, which has not been rendered, and $1.75 for a wood-cut not yet finished. Our net assets are, therefore, about $1,460. Subtracting from this sum the advance dues received, we have a balance of about $830 belonging to the fiscal year 1886, as compared with a similar balance of $728, belonging to the fiscal year 1885, or $102 increase in our present balance. The number of the Proceedings now in preparation, and properly belonging to 1886, will consume a portion of this difference, but we may, nevertheless, feel that we are a little better off financially than we were one year ago.

MEETINGS.

Regular,	12
Business,	6
Total,	18

The Board of Directors have held but three business meetings, the regular business having been so arranged as to require but little detail attention by the Board.

ATTENDANCE.

	1886.	1885.
Members, total,	479	712
" average,	27—	42—
Visitors, total,	20	46

This falling off in attendance is such as may, of course, be expected during times, like the past year, of great professional activity.

Continuing the Membership table from my last Report (Vol. V., No. 3, p. 258), we have

	HON.	COR.	ACT.	ASSOC.
Membership at end of fiscal year 1885,	3	5	423	8
Additions,			41	1
			464	
Deceased,			4	
			460	
Resignations, etc.,			9	
	3	5	451	9

The net increase of Active Membership has been about $6\frac{6}{10}$ per cent.

The residence of our Active Membership is now as follows:

Philadelphia,	224	Minnesota,	2
Pennsylvania, outside of Philadelphia,	100	Vermont,	1
New York,	32	Rhode Island,	1
New Jersey,	14	North Carolina,	1
Virginia,	14	Louisiana,	1
Missouri,	6	Texas,	1
Colorado,	6	Michigan,	1
Massachusetts,	4	Indiana,	1
Delaware,	4	Kentucky,	1
District of Columbia,	4	Iowa,	1
Illinois,	4	Idaho,	1
Connecticut,	3	Arizona,	1
Ohio,	3	U. S. Colombia,	2
Kansas,	3	Austria,	1
Nebraska,	3	Japan,	1
Maryland,	2	New Zealand,	1
West Virginia,	2	Cuba,	1
Georgia,	2		451
Alabama,	2		

We have, therefore, two more members residing without than within the City of Philadelphia.

We have lost by death another four of our most respected Active Members: Frank S. Brock, Wm. B. Cooper, E. F. Loiseau and Joseph B. Wilson.

The following Original Papers have been read before the Club during the year:

The Greathead System of Fire Protection and the Public Supply of Hydraulic Power, by Howard Constable.

Harbor Studies, by Prof. L. M. Haupt.

Railways in Japan, by Mataro Crizuka.

The Present Situation of the Interoceanic Canal Question, by J. Foster Crowell.

Some Engineering Features of the Nicaragua Ship Canal, by J. Foster Crowell.

A Practical Test to Operate a Distant Signal by a Wire Run Through a Pipe Filled with Oil, by Wm. H. Dechant.

The Steel Rail Discussion, by F. H. Lewis.

Discussion of Mr. C. W. Buchholz's Paper on "Engineering; Its Achievements and Its Reward," by J. S. Elliott.

Pressure and Composition of Natural Gas, by Dr. H. M. Chance.

Notes upon the Early History of the Employment of Water Power for Supplying the City with Water, and the Building and Re-building of the Dam at Fairmount, by Frederic Graff.

Calorimetric Tests of Boilers, by J. E. Codman.

Taper of Steam Jets, by G. R. Henderson.

The Movement of Ice in the Delaware River, by Captain S. C. McCorkle.

Notes on the Investigation of the Movement of Freight and Passengers in Cities, by Gratz Mordecai.

Photographic Map Reduction, by O. B. Harden.

Horizontal Turbines at Willimantic, by John Graham, Jr.

A Review of the Freight Brake Trials, by W. E. Hall.

A Case of Low Water in a Steel Boiler, by J. E. Codman.

Early Mining Operations in Berks and Chester Counties, by J. H. Harden.

Car Lubrication, by W. E. Hall.

Accidents in Anthracite Mines, by Frank A. Hill.

Efficiency of Locomotives and Resistance of Trains, by G. R. Henderson.

The St. Paul Ice Palace, by Herman Haupt, Jr.

Analogies between Electrical and Mechanical Units and Phenomena, by Carl Hering.

Water Pipes, by A. H. Howland.

Present Investigation of the Drainage and Water Supply of Chicago, by Rudolph Hering.

The Equilibrium and Stability of the Floating Current Deflectors, Designed for Harbor and River Improvements (Supplement to Harbor Studies), by Prof. L. M. Haupt.

Stand Pipes, by A. H. Howland.

Chester Co., Penna., Granite Quarries, by J. H. Harden.

The following contributions have been made to the Club Reference Book:

Table of Sizes of Chimneys, by H. K. Lee.

A Table of Approximate Metric Equivalents, by Fred. Brooks, C. E. (Correspondent).

Table of Equivalents of Units of Energy and Equivalents of Units of Weights and Measures, by Carl Hering.

A Table of Millimetres and Equivalents in Inches, by G. R. Henderson.

Thickness of Plates for Stand Pipes, with Formulæ, by Kenneth Allen.

The following Mathematical Questions were offered by T. Earl Collins:

Does a Locomotive Piston at the end of each stroke, in reversing its direction, come to a stand-still, and if so, can the same be mathematically demonstrated?

Also, would a difference in speed affect the duration of its stationary condition, if such exists?

Answer by A. Marichal.

The following Notes and Communications have been presented:

A Novel Rubber and Steel Spring, by Howard Constable.

Gas Burners, by A. R. Cruse.

Isthmian Transits, by Prof. J. E. Nourse (Correspondent).

The Behavior of Water in a Double Siphon, by Dr. H. M. Chance.

A Rolling Lock Gate, by J. Foster Crowell.

Baird's Water Distiller, by C. W. Pusey.

New Double Lathes for Turning Steel-Tired Car Wheels, by W. H. Derbyshire and F. W. Gordon.

Davis' Self-Timing Anemometer, by J. H. Harden.

Atlantic City Drainage, by J. F. Wood.

Intermittent Syphons, by C. G. Darrach.

Recent Steam Gauging for the Future Water Supply of Philadelphia, by H. W. Sanborn.

Cornwall Iron Mines, Lebanon Co., Pa., by E. V. d'Invilliers.

Model of Same, by A. E. Lehman.

A Device for Closing Frog Throats in Railroad Crossings, by A. R. Roberts.

First Permanent Tramway in America, by Dr. R. P. Robins (Visitor).

Designs for Dams No. 3 and 4 on the Lehigh, by Prof. L. M. Haupt.

Extracts from Mr. H. R. Stoops' Paper on the Philadelphia Traction Co.'s Lines, by Prof. L. M. Haupt.

Notes upon Hon. John Bigelow's Report on the Panama Canal, by E. S. Hutchinson.

Corrections to Nystrom's Engineers' Pocket-Book, by P. D. Ford.

Construction in Earthquake Countries, by Prof. L. M. Haupt.

Corbett's Improvements in Solar, Mining and Engineers' Transits, by Prof. L. M. Haupt.

A New Application of the Dynamometer, by W. E. Lockwood (Visitor).

Efficiency of Different Forms of Boilers now in use by Philadelphia Water Department, by J. E. Codman, with discussion by Washington Jones.

Respectfully submitted,

HOWARD MURPHY, *Secretary and Treasurer.*

CONTRIBUTIONS TO THE LIBRARY.

FROM NOVEMBER 1ST, 1886, TO APRIL 8TH, 1887.

From the INSTITUTION OF CIVIL ENGINEERS, London.

Farrar—Gold-Fields of South America.
Thwaite—Heliography.
Kennedy—The Bilbao Iron-Works.
Andrews—Effect of Temperature on Strength of Railway Axles.
Breffault—Constantinople Water-Works.
Cowan—The Carrou Iron-Works, Scotland.
Max Am. Ende—Formulas for the Weights of Girder Bridges.
Grünewald—The Viaduct over the River Retiro.
Hunter—Locomotive Engine and Carriage-Sheds.
Wolters—Manufacture of Rolled Joists in Belgium.
Concrete as applied in the Construction of Harbors.
Hopkinson—The Electric Lighthouses of Macquarie and of Tino.
Kennedy—Engineering Laboratories.
Willcocks—Irrigation in Lower Egypt.
Shield—Harbor Works in Algoa Bay, Cape Colony.
Hedges—Central-Station Electric Lighting.
Hetherington—Utilizing Waste Air in Filter-Pressing.
Bagshaw—Friction-Clutches.
Seyrig—Iron Skeleton of the Statue of Liberty on Bedloe's Island, New York Harbor.
Waring—Siphon Outlet for a Low Sewer.
Dibdin and Crimp—Disposal of Sewage-Sludge.
Abstracts of Papers in Foreign Transactions and Periodicals. Vol. LXXXVII.

From the SOCIETY OF ENGINEERS, London.

Rules, By-Laws and List of Members, etc., 1887.
Inaugural Address of the President, Prof. Henry Robinson, Feb. 7th, 1887.

From the NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, Newcastle-upon-Tyne.

Transactions—Vol. XXXV., Part IV. Vol. XXXVI., Part I.

From the LIVERPOOL ENGINEERING SOCIETY.

Transactions—Vol. VI. Session, 1885.

From the SOCIETY OF CIVIL ENGINEERS, Paris.

Mémoires—July, Aug., Sept., Oct., Nov., Dec., 1886; Jan., 1887.
Séance du 5 Novembre, du 3 Decembre, 1886; du 7 Janvier, du 18 Fevrier, 1887.

From L'ADMINISTRATION DES PONTS ET CHAUSSEÉS, Paris.

Annales—Sept., Oct., Nov., Dec., 1886; Jan., 1887.
Personnel. 1887.

From the AUSTRIAN SOCIETY OF ENGINEERS AND ARCHITECTS, Vienna, Austria.

Zeitschrift, Part III, Part IV. 1886.
Wochenschrift.

From the VEREIN FUR BAUKUNDE, Stuttgart, Germany.

Proceedings—Part I. 1886–87.

From the SAXONIAN SOCIETY OF ENGINEERS AND ARCHITECTS, Leipzig.

Der Civilingenieur.
Catalogue. 1886.

From the NORWEGIAN SOCIETY OF ENGINEERS AND ARCHITECTS, Kristiania.

Norsk Teknisk Tidsskrift, Parts 5–6. 1886.

From the SWEDISH SOCIETY OF CIVIL ENGINEERS, Stockholm.

Proceedings—Fjerde Häftet. 1886.

From the PORTUGESE SOCIETY OF CIVIL ENGINEERS, Lisbon.

Revista de Obras Publicas E. Minas—Jan.-Feb., Sept.-Oct. and Nov.-Dec., 1886.

From the ARGENTINE SCIENTIFIC SOCIETY, Buenos Aires.

Anales—Sept., Oct., Nov., Dec., 1886.

From the MINISTERO DEI LAVORI PUBBLICI, Rome, Italy.

Giornale del Genio Civile—April, May, 1881. Nos. 1 to 12, both inclusive. 1886.

From the IMPERIAL UNIVERSITY, Tokio, Japan, Mr. H. Watanabe, President.

Calendar for 1886–87.

From GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA, Montreal.

Annual Report (new series), Vol. I. 1885.

Maps to accompany ditto.

From the BRITISH PATENT OFFICE, London.

Abridgments of the Specifications of Patents for Inventions relating to

Fire-Arms, Ammunition, etc. Division 1. 1886.

" " " 2. 1886.

Preparing and Cutting Cork; Bottling Liquids; Securing and Opening Bottles, etc. 1885.

Drains and Sewers, Sewage and Manure. 1885.

Photography. 1885.

From the WINNIPEG BOARD OF TRADE, Winnipeg.

Eighth Annual Report for 1886.

From the AMERICAN SOCIETY OF CIVIL ENGINEERS, N. Y.

Transactions—Aug., Sept., Oct., Nov., 1886.

Constitution, By-Laws and List of Members, Sept., 1886.

From the AMERICAN INTSITUTE OF MINING ENGINEERS, N. Y.

Transactions—Advance Sheets.

Hitchcock—Geological Map of the United States and part of Canada. 1886.

From the AMERICAN SOCIETY OF MECHANICAL ENGINEERS, N. Y.

List of Members, Rules, Jan. 1st, 1887. (2 copies.)

From the AMERICAN IRON AND STEEL ASSOCIATION, Philadelphia.

Bulletin.

From the U. S. ASSOCIATION OF CHARCOAL IRON WORKERS.

Journal—Vol. VII, No. 3. 1886.

From the ASSOCIATION OF ENGINEERING SOCIETIES, N. Y.

Journal—Oct., Nov., Dec., 1886; Jan. (with supplement), 1887.

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From MR. ALBERT F. NOYES, City Engineer, West Newton, Mass.

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Reports of the Chief Engineer of the Aqueduct Commission, and the Chief Engineer and Consulting Engineer of Department of Public Works, to the Aqueduct Commissioners in Relation to Constructing the Quaker Bridge Dam and Reservoir. Feb., 1886.

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From MAJOR H. W. CLARKE, Active Member of the Club.

Report of the Regents' Boundary Commission upon the New York and Pennsylvania Boundary, with the Final Report of Major H. W. Clarke, C. E., Surveyor for the Commission. 1886.

From the Author, MR. E. L. CORTHELL, Active Member of the Club.

The Isthmian Ship-Railway—Address before New York Academy of Science, Dec. 20th, 1886.

From PROF. L. M. HAUPT, Active Member of the Club.

River and Harbor Improvements, with Special Reference to the Problem of the New York Entrance. Haupt's System of Floating Deflectors, etc. Opinions. 1886.

From MR. RUDOLPH HERING, Active Member of the Club, Chief Engineer.

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From CAPT. O. E. MICHAELIS, Active Member of the Club.

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Specifications for Cast Iron Pumping and Supply Mains, Special Castings, etc. 1887.

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Sixteenth Annual Report for 1886.

ADDITIONS TO EXCHANGE LIST.

GIORNALE DEL GENIO CIVILE, compilate sotto L'alta Direzione del Ministero dei Lavori Pubblici, Rome, Italy.

NEW YORK ACADEMY OF SCIENCES.

THE ENGINEERING SOCIETY OF LEHIGH UNIVERSITY, Bethlehem, Pa.

ENGINEERS' CLUB OF KANSAS CITY.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

NOTE.—The Club, as a body, is not responsible for the facts and opinions advanced in its publications.

Vol. VI.] DECEMBER, 1887. [No. 3.

XVIII.

NOTES ON THE PREPARATION OF ANTHRACITE COAL.

By EDWIN LUDLOW, Active Member of the Club.

Read April 16th, 1887.

I DESIRE to call the attention of the members of this Club, and especially those who are mechanical engineers and have the bump of inventiveness well developed, to one of the greatest needs now met with in the preparation of anthracite coal. While engineering ability and mechanical skill has done wonders during the last decade toward putting the mining and preparation of coal on a scientific basis—making it possible to ship as high as 2,600 tons of prepared coal from one breaker in a single day—still in every breaker, no matter how modern it may be, one will find the chutes, through which the coal passes from the screens to the loading pockets, lined with boys from 12 to 14 years of age, who sit there 10 hours a day, picking by hand the slate from the coal as it passes along. The atmosphere of this screen room is in many cases so laden with fine coal dust that objects can not be distinguished 20 feet away, and while the breathing of this coal dust does not seem to have any immediate effect on the boys' health, it undoubtedly lays the seeds for the bane of the coal region—miners' consumption. It strikes every

thoughtful man who looks down on from 100 to 200 boys working in a single breaker, that it is a very crude and expensive way of preparing coal.

Various appliances have, of course, been designed, but the only really successful one, as proved by actual experience, has been the water jig. This undoubtedly removes the slate with a small percentage of waste of coal, and where the product of the mine is wet and water has to be used on the screens to effect a separation of the dirt from the coal, it is the best and most economical appliance that can be employed. But the greater part of the coal going to market comes from dry mines, where it would be a detriment to the quality of the coal and a great expense to use water.

The waste water from the jig is also expensive to take care of, as in most localities it is no longer allowable to let it run with the fine dirt it holds in solution into the nearest creek, as the sediment will carry a long distance and invariably deposits itself where it will do the most harm and entail a heavy suit for damages.

Enough tanks have, therefore, to be provided to allow all the waste water to thoroughly settle, so that the water and culm can be removed separately. Water itself, or rather the pure article, is both scarce and expensive during a part of each year throughout nearly the whole region. And if mine water is used, as is generally the case, the acid contained in it attacks the iron work of the jig and makes frequent repairs necessary.

The principle the jig works on is based on the difference in specific gravity between coal and slate. The two enter the bottom of the jig together, and by the pulsations of a large plunger in an adjoining compartment, water is forced up through the coal, lifting it and allowing a fresh supply to come in.

The coal is forced to the top and runs off with the water, while the slate, owing to its greater specific gravity, passes out through a separate opening in the bottom.

Now what is needed, and what I hope some member of this Club will devise, is a dry jig, in which this separation will be effected by the use of air instead of water.

One of the difficulties encountered in getting up such a jig is

caused by the care with which coal has to be handled to prevent its chipping or breaking. It cannot be dropped on iron or even on itself, without producing an appreciable percentage of waste. With the most approved rolls the loss in rebreaking any size to a smaller one amounts to from 10 to 15 per cent.

While the difference in specific gravity between coal and slate of the same sized pieces is very great, still trouble would be experienced in any separation by an air current with flat pieces of both slate and coal, on which the action of the air would vary according to whether it acted on the edge or the whole side.

The man who invents a successful dry jig that will stand the test of actual trial, will undoubtedly make a very handsome amount by it. Not to be too cumbersome a single jig should not have a greater capacity than 500 tons per day, and as the shipping capacity of the anthracite region is about 200,000 tons per day, it would take about 400 to supply the trade.

I shall always be most happy to furnish any information, or give any assistance in my power, to any one desiring to work on this matter.

XIX.

SOME REMARKABLE BREAKS IN A RESERVOIR.

By Lewis N. Lukens, Active Member of the Club.

Read May 7th, 1887.

The reservoir was built in 1873, on the top of the Conshohocken hill, about 200 feet above the level of the Schuylkill River, from which the water is pumped. In plan it is a square of 151 feet at the top of the embankment, with a division embankment rising half way to the top of the side walls. When ordinarily full it holds about 1,000,000 gallons.

The earth of the locality is of a rather light character, with enough talc in it to make it feel rather greasy. The general rocks of the locality are limestone, and the variety quarried and

sold as Conshohocken stone. The exact geological conditions of the locality I have not knowledge enough to describe.

In constructing the reservoir the banks were raised about as much above the natural level as the excavation was beneath it, the earth from the excavation being used for the embankments. These were well rolled and allowed to settle as much as possible in the course of construction. The bottom and sides were then lined with 18 in. of stiff fire-clay, put on in layers of about 3 in., each layer being well rammed. Above this there was put a brick pavement, and this was washed over with hydraulic cement.

The inlet and outlet pipes were, as shown in the drawing, cast-iron pipes laid in masonry. This masonry was composed of ordinary undressed stone, laid in hydraulic cement, and extended out to about the middle of the embankment.

The reservoir was finished in the Fall of 1873, and water was let in soon after. In December, 1873, only a few months after the water was let in, the first break occurred. This break commenced just above the outlet pipe, and followed the line of the pipe through the embankment, laying bare some of the masonry described as surrounding the pipe. It broke through the embankment just about at the natural level of the ground, and was about 15 feet across at the top of the embankment, narrowing, of course, toward the bottom. The curious part was, however, that instead of the ground below showing evidence of such a large body of water passing over it, it showed that only a comparatively small part of the water had escaped that way and covered the low land just below. The larger part of the water must have escaped by some other channel, necessarily a subterranean one. This first break was repaired by filling in with stiff fire-clay and finishing as before. In the Summer of 1876 the second break occurred. This was in the middle of the west compartment, and was an absolute giving way of the bottom, there being no break in the side. It was simply a hole of about 20 feet in diameter and of indefinite depth. A line was let down at least 85 feet without finding bottom, and stones thrown in seemed to rattle down indefinitely. The ledges of rock seemed to be inclined toward each other thus $\vee$, and the slippery talcose earth had been washed from between them, nobody knows where. Whether

the water from the first break started it, is, of course, not known, although it seems at least possible. In repairing this the crevices between the rocks were filled up and arched over with masonry, going as deep as necessary to get a solid support for the masonry, in one case as much as 34 feet below the bottom of the basin. The hole was then filled in with stiff clay and iron-ore screenings, principally clay. The top was then planked over with hemlock plank, and the clay lining rammed down and covered with brick as before.

In the Spring of 1879, three years after, the third break occurred. This was in the other compartment, taking away part of the partition wall and part of the bottom, and was a good deal like the preceding one. An interesting fact is, that a well near by, 80 feet deep, and which had had 8 or 10 feet of water in it, was completely emptied the night the break occurred, and has not held any water since. There must have been some underground channel by which the water from both found its way to the river.

This hole was filled up with masonry and clay like the other. The clay lining was then taken off, and the whole basin, sides, bottom and partition embankment was planked over with heavy hemlock plank. The clay was then put on again to a depth of 14 inches, and the whole surface bricked as before. This time it lasted for eight years, until last Fall, when a small break occurred. Some small quantity of water had washed the earth from between two rocks in the side of and near the bottom of the end embankment in the same old way. The weight of the superincumbent water had then sprung back the side planks, and the water had escaped by some underground channel. Being relieved of the weight the planks had sprung back. The fact of the springing back and subsequent release is shown by there being a number of small fish caught and crushed in the cracks. This was repaired as usual by filling in with fire-clay, and at that particular place there is now three feet of fire-clay, rammed in between the rocks, then the planking, then 14 inches more clay and then the brick lining. It is hoped now that it will last.

XX.

THE DIMENSIONS OF PIPE FLANGES AND CAST IRON PIPES.

By J. E. Codman, Active Member of the Club.

Read May 21st, 1887.

The object of the present paper and diagram is to bring before the members of the Club the subject of *diameters of Flanges, diameter of Bolt circle, size and number of Bolts and thickness of cast iron pipe.*

It is proposed by means of the diagram to give graphically a standard for adoption, arranged in such manner as to be easily understood and readily applied.

All mechanics know that the flanges used in different foundries, on the same diameter of pipe, are not of the same outside diameter, do not contain the same number of bolts, nor bolts of the same size. This creates confusion, especially in repair work in large establishments, where, perhaps, a portion of the work is furnished by different contractors. It often occurs that a valve or a piece of pipe requires changing from one place to another. Upon examination it is found that although the inside diameter of pipe or valve may be the same, yet there is a difference of from $\frac{1}{2}$ inch to 1 inch in the outside diameter of flanges; one may have 1 inch bolts and the other only $\frac{5}{8}$, one may have four in number and the other six, and a corresponding difference in the diameter of bolt circles. Just why this difference should occur I am at a loss to explain, other than from a difference of opinion on the subject. It seems possible to make good steam and water tight joints in cast iron pipe of a standard size, and have them so proportioned that a corresponding relation will be maintained between the different sizes.

A very common trouble is the inclination to put too few bolts in a flange to hold the joint for any length of time under pressure, and another to place bolts of a small size on a bolt circle of large diameter.

Several tables are published giving diameters of flanges and numbers and sizes of bolts, in which a $\frac{7}{8}$-inch bolt is given as a

suitable size for a 48-inch pipe under a pressure of 100 pounds per square inch. In practice, and especially after pipe has been exposed and oxidation has proceeded to a greater or less extent upon the nuts and heads of bolts, it will be found difficult to keep the joint tight if success be attained in making it so in the first place.

From practical experience as well as from observation, joints in a 48-inch pipe, made with bolts $1\frac{1}{4}$-inch diameter on a bolt circle of 55 inches diameter and spaced at a distance of nearly 4.3 inches from centre to centre, have been found to give satisfactory results in every case, and no trouble has been experienced, either in making the joint, or keeping it tight thereafter. In making a computation for strength of the joint with bolts of this size, based upon the net section of bolts compared with the strength of flange, it will be found that a large margin of strength in excess of the flange is found in the bolts; the same result is reached in the 36-inch pipe, using $1\frac{1}{8}$-inch bolts on a bolt circle 42 inches diameter, and bolts spaced about the same distance apart as in the 48-inch pipe; also for the 30-inch, 20-inch, 16-inch and 12-inch. All these sizes have been under practical observation for several years and have been in use upon water pipe with excellent results.

The excess of strength in bolts, it seems, must be utilized in the strain put upon them to make the joint. This strain, of course, is uncertain, and no doubt at times with small bolts exceeds the limit of elasticity of the material. With one bolt strained beyond the elastic limit, the work thrown upon the adjoining ones is considerably increased, and at every change of temperature, or from any unequal settling of the pipe, the joint leaks.

From observation and experience the most common cause of leaky joints can be directly traced to either small bolts, or too few of them, or both combined. The late Joseph Harrison, Jr., said to the writer that "he did not wish bolts used in the proposed traction engine he was constructing," just before his death, "less than one inch in diameter."

The thickness of pipe by the diagram has been taken from pipe in practical use, and from tables and comparisons made and collected of cast iron pipe under pressure in various cities and foundries in the United States.

In the diagram before us the pressure has been taken at 100 pounds per square inch; strength of the cast iron at 15,000 per square inch.

The principal object of the diagram of thickness is to show graphically some points that appear from it, which perhaps have not been brought out before in the same form, at least not to the knowledge of the writer.

It is to be observed that the practical thickness from zero diameter to 48-inch diameter, when expressed in function of the theoretical thickness and plotted to scale upon a diagram in which the abscissae, shall be the diameters, and the ordinates shall represent the function, there will be described a curve for which the following equation can be made: $c = 7 + \frac{98}{D}$ in which c equals a co-efficient found by dividing the practical thickness t by the theoretical thickness t^1, or $\frac{t}{t^1} = c$; D = diameter in inches.

In the equation, the quantity 7 is a constant and is made parallel to the line of diameter; it is also an asymptote to the remaining portion of the equation, which is affected by the variable D, and which forms the equilateral hyperbola. The portion of the diagram shaded by cross-lines between the asymptotes and the curve is designated as the co-efficient for handling, while the portion between the asymptotes and the line of diameters has been designated as the co-efficient for safety. It is to be remembered that these two co-efficients are so designated for convenience as parts of the equation, and the sum of both form the co-efficient c.

The diagram is drawn to show graphically the thickness for tensile strength = 15,000 pounds, and pressure = 100; to show graphically the thickness for tensile strength = 18,000 or 20,000 pounds. The scale can be made 1.2 and 1.33 larger. Scales for 15, 18 and 20 are given in the margin of the diagram.

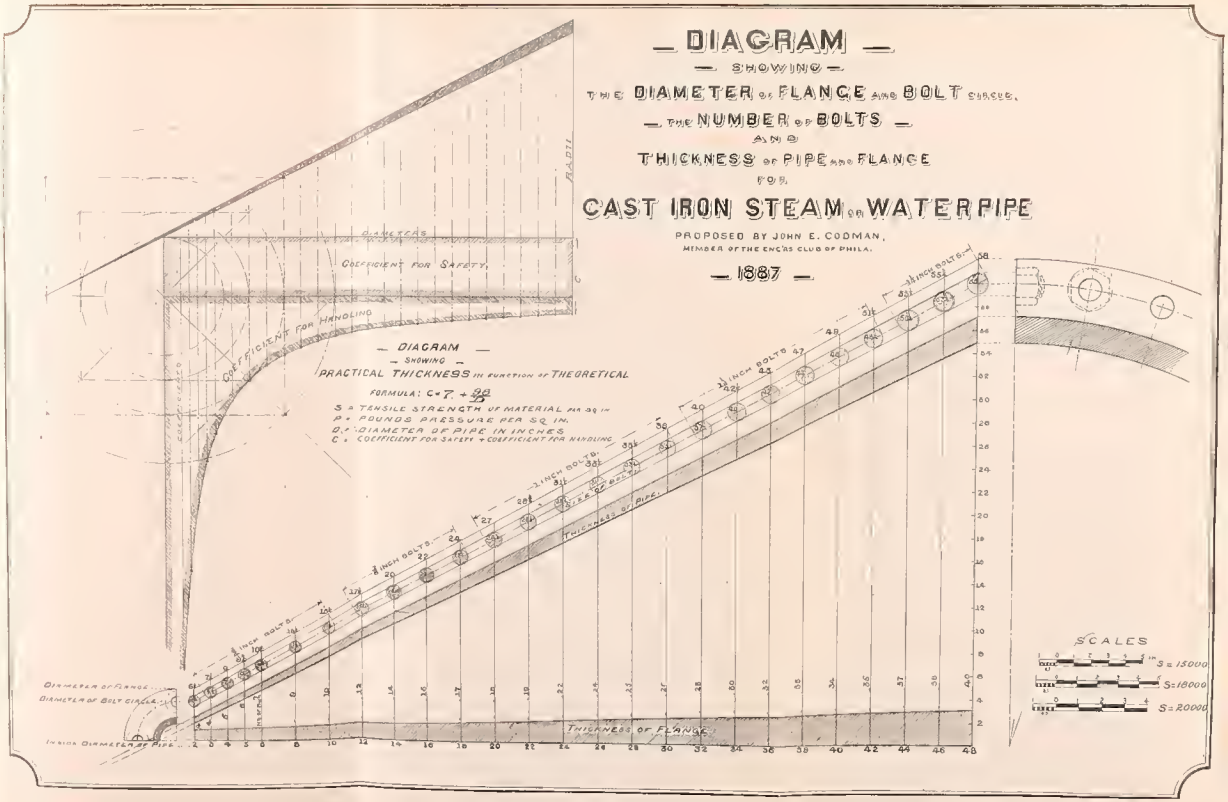
DIAGRAM
SHOWING
THE DIAMETER OF FLANGE AND BOLT CIRCLE,
THE NUMBER OF BOLTS
AND
THICKNESS OF PIPE AND FLANGE
FOR
CAST IRON STEAM OR WATER PIPE
PROPOSED BY JOHN E. CODMAN,
MEMBER OF THE ENG'RS CLUB OF PHILA.
1887
DIAGRAM
SHOWING
PRACTICAL THICKNESS IN FUNCTION OF THEORETICAL
FORMULA: C = T + PD/S
S = TENSILE STRENGTH OF MATERIAL PER SQ. IN.
P = POUNDS PRESSURE PER SQ. IN.
D = DIAMETER OF PIPE IN INCHES.
C = COEFFICIENT FOR SAFETY + COEFFICIENT FOR HANDLING
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XXI.

A VENETIAN SHIP RAILWAY.

By E. L. Corthell, Active Member of the Club.

Read June 18th, 1887.

Through the courtesy of Gen. F. L. Hagadorn, of Chicago, the writer is enabled to present an interesting sketch of a Ship Railway project, conceived and executed by Sorbolo, a Civil Engineer of Venice. This extraordinary feat was performed about four and a-half centuries ago.

This paper is an abstract from a volume entitled "Venice and the Venetians," by Marsh. The story is now told as bearing upon the question of surmounting the American isthmus by similar means. The character of the two Engineers, one the executor of the Venetian Ship Railway project and the other the projector of a much more important and permanent work of this kind, are in many respects similar. Both were men of bold projects, of carefulness of details, and of entire confidence in their plans, and it is not too much to say that the Engineer of the Modern Ship Railway, had he lived, would have as surely seen the success of his project as Sorbolo witnessed the success of his bold undertaking.

The American Consul at Venice, Mr. H. Abert Johnson, has kindly furnished the sketches of the vessels of that day similar to those transported from Venice to Lake Garda over Mount Peneda. The following is an extract from his letter, dated Venice, April 17th, 1887:

"I send you drawings of the three types of vessels used in this expedition, as described by Sorbellica 'della Storia Veneta,' consisting of galleys and small boats called "Coppano." The two types of galleys used are shown in drawings No. 1 and No. 2; the length of types Nos. 1 and 2 averaged 45 metres (147.6 feet), breadth of beam being variable, but usually within 39 or 40 feet. The 'coppano,' No. 3, as you see by the drawing, was nothing much more than the ordinary modern fishing boat. No. 1 is copied from a picture in the Royal Academy here, and

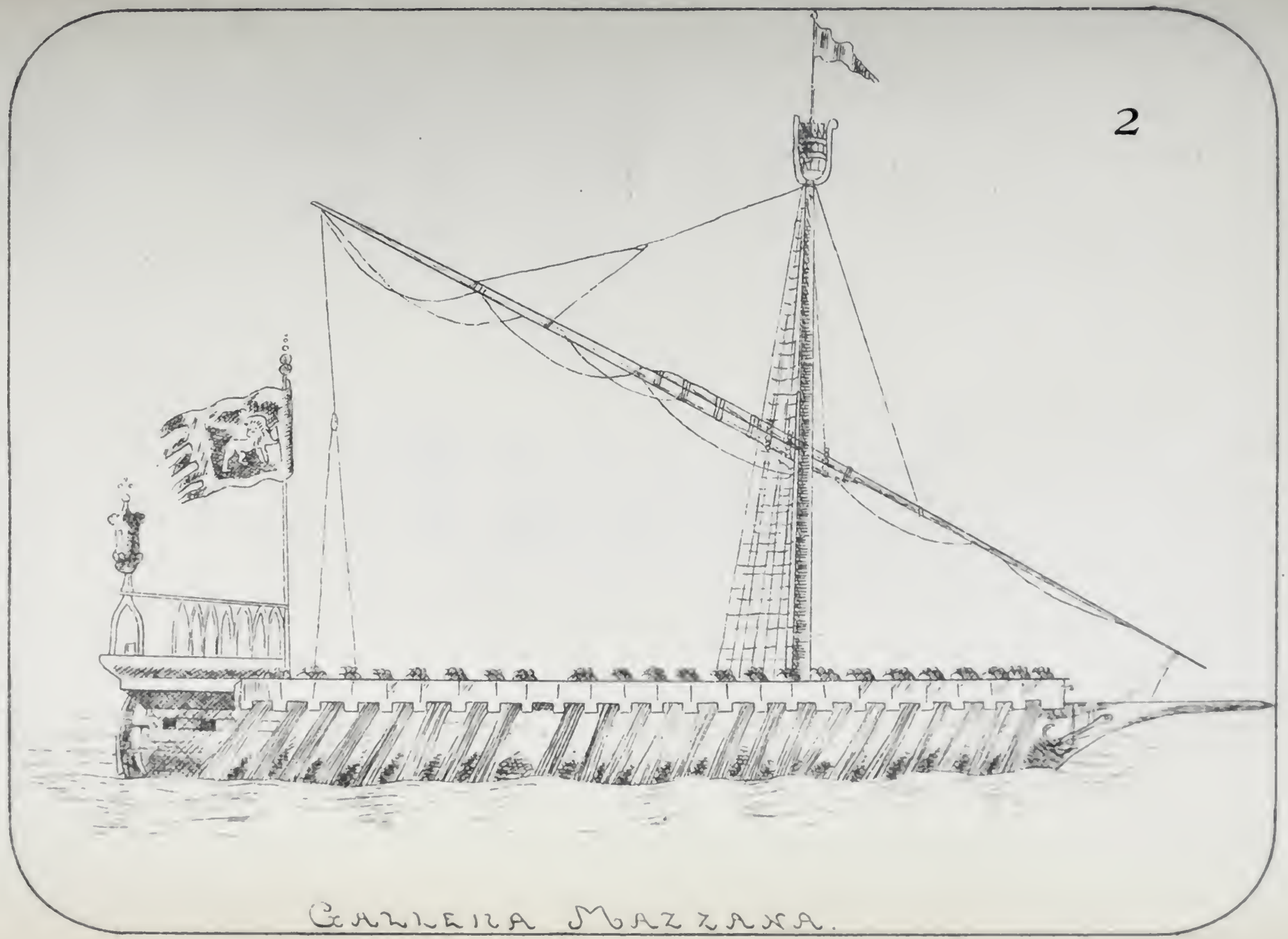
No. 2 is taken from a wooden model in the Arsenal. No. 3 from a painting by Carpaccio."

The accompanying sketch of the route is from maps in the Rooms of the American Geographical Society in New York.

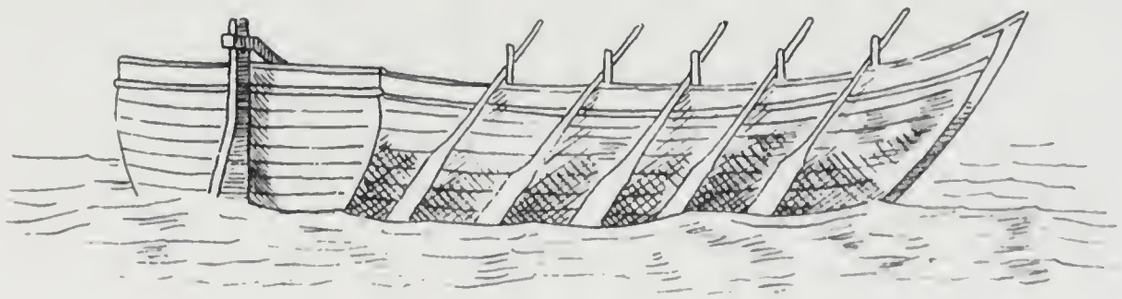
The recent occupation of the City of Brescia has called renewed attention to this stronghold, which has figured extensively for many centuries in the predatory wars of the Italian States. It is an inland Gibraltar, the key of a highly productive territory, stretching from the foot of the Lombardian Alps and commanding an extensive commerce, the lake, Garda, only a few miles distant, being the western boundary of Venetia. Brescia is built upon the summit of an extensive hill, surrounded by three successive walls, between each of which there are vast plains sufficient for the encampment of an army and for the maintenance of herds of cattle and sheep in case of siege; and from the centre of the city towers the ancient citadel, commanding every acre of ground within the walls. It is in every respect a remarkable place, but in nothing more so than in the fact that something like four and a-half centuries ago, during one of its memorable sieges, it was relieved by a novel expedition sent overland by the Venetians. Immense galleys, fully manned and armed with the ponderous stone-throwing artillery of the period, were safely conveyed from the waters of the Adriatic over the plains and mountains of Italy to the Lake Garda, to do doughty warfare upon the besieging enemies of Brescia, riding quietly at anchor upon the waters of the lake.

The garrison and the people of Brescia had been reduced to the direst extremities, and the Milanese were in possession of all the approaches. The best engineers of Venice had discussed for many days, in the presence of the Senate, a variety of modes for effecting the desired object, and the one ultimately adopted was a scheme so bold and novel at the time as to surpass everything that had been before attempted. Of course it met with the loud execrations and ridicule of all the experienced engineers of Venice. But the man who suggested it was equal to the occasion and knew his ground. He had spent many years in superintending engineering works of considerable magnitude in the Venetian territory, and had also had some experience as a soldier,

1
GALLERA SOTTILE


2
GALLERA MAZZARA.

3



BOPPANO

and knew how to handle troops. He requested that he might have an interview with the Doge and the Council, and his request was granted. He boldly stated that he was prepared to submit a plan which would afford the necessary relief to the beleaguered city. The Doge and the Council looked upon him with incredulity, wondering what fresh proposal could possibly be made by one so little known. They saw before them a man short of stature, with restless eyes and black hair, cut short about his ears, with a voice almost effeminate, but who certainly made up for his insignificant appearance by the boldness of his proposal. At a signal from the Doge, Sorbolo commenced his speech.

"Most Serene Prince," said he, "I have come to unfold a plan which I have conceived, whereby you may afford the necessary relief to the most noble city of Brescia, by placing a flotilla of ships upon the Lake Garda. It is well known that the passage by the Mincio is closed, owing to the treachery of the Duke of Mantua. Therefore there only remains the Adige available for the purpose, which I am about to submit to this reverend Assembly. I know the stream as well as I know the Grand Canal. In winter it is swollen by the rains from the mountains, and is deep enough for the passage of the largest galley. I therefore humbly suggest that up this river a fleet of ships should be sent to a point fifty miles distant from the Gulf of Venice. From thence there is a long, level country, across which it were a very easy task to carry the largest-sized ships, provided men and oxen were furnished. The chief difficulty which will beset the path is presented by the mountain of Peneda, which rises abruptly to a considerable height from the shores of a small lake through which I propose to pass. But this will not present an insurmountable difficulty. Having crossed the mountain, the Lake Garda is only twelve miles distant."

The venerable Doge and the august members of the Council listened in profound silence to the proposition. At first the thought occurred that the proposer must be mad. But on finishing his statement, he drew forth from a small box which he had brought with him the model of a galley, and before the view of the whole Assembly placed it upon a cradle of the kind he proposed to construct, on which to transport it overland. The plan

was so simple that the doubts of the members of the College were entirely and at once swept away. The keel of the ship was fastened upon a small platform furnished with wheels; and from the projecting sides of the vessel there dropped pieces of wood, which were fastened to other pieces fixed at right angles in the frame-work of the keel. Where these two pieces of timber joined to each other wheels were placed, so that the whole mass could, by the appliance of sufficient power, be drawn along the ground.

Sorbolo was dismissed with compliments by the Doge, and the whole matter was afterward laid before the Grand Council, by whom it was ultimately adopted, and the necessary instructions given for the preparation of a fleet suitable for the enterprise. The mode of conveyance was kept a profound secret, and no soldier knew the plan until fifty miles from the coast Sorbolo first put it into use. The Senate had given instructions for the preparation of six galleys, two of which were first-rate ships, and the remaining four second-rate. In addition to these were twenty-five light barques, forming a most useful flotilla for the purpose designed. The galleys were fitted with all the appliances necessary for a naval combat—with heavy cannon, with stone balls, with large stores of cross-bows, arrows, lances and all the usual munitions of the period necessary for conflict with the enemy.

The command of the fleet and armament was given to Pietro Zeno, and it sailed from Venice in the middle of December, 1438. On reaching the mouth of the Adige ample water was found to float the vessels, but the current was so strong that it was necessary not only to make use of the sails and rowers, but also of men with ropes to assist in drawing the vessels against the stream. This portion of the journey consumed one-half the time occupied in reaching the lake, and at the end of six weeks only fifty miles of water had been traversed. Then began the labor of transporting the ships across the land. The soldiers and mariners were astounded when they were informed by Zeno and their captains that the ships were to be transported overland. They were incredulous, but Sorbolo's measures were complete. While the platforms with wheels which they had brought from Venice were being put together, a channel was dug in the bed of the river in which the frame-work was placed, and then the galleys were

towed, one after the other, on their new cradles, and oxen attached to them drew them without difficulty to the level ground. Sorbolo had dispatched agents beforehand; and when the expedition arrived at the point chosen for the overland route, they found the fields filled with oxen which had been brought for the use of the Republic. It required the united strength of 600 oxen to draw each galley out of the water, but when they were fairly landed and on their ways, the largest of them were moved with ease by 300; and under the direction of the peasants who came with them, the oxen did their work in splendid style. Galley after galley was drawn from the river to the plain, and when the six largest ships stood in a row, the appearance which they presented was most curious. Their masts towered far above the tops of the trees in their vicinity, and their huge hulks, bolstered high and dry upon the land, were objects of astonishment and curiosity to all who beheld them. The ground for nearly thirty miles of the remaining fifty was quite level, and a hard frost had turned the fields into roads over which the ships passed without difficulty.

The soldiers, divested of their armor, joined the mariners and rowers, and were separated into working parties, distributed among the galleys and the barques, each furnished with levers, rollers, ropes, windlasses and wedges, as well as spades and pick-axes, in sufficient quantity to enable the men to rapidly level the way before them as they progressed.

When the whole fleet had been raised from the river and placed on land, and everything arranged for an onward movement, Zeno ordered the men to repose for the night, placing a strong guard over the oxen and peasants who had been hired for the expedition. But with the dawn of day the passage over the new-made roads began. Nearly 3,000 oxen were engaged in drawing the vessels, and of these 1,800 were attached to the six largest galleys. The barques, mounted upon small wooden carriages of great strength, fitted with substantial rollers, gave very little trouble. The fields were covered with snow, and a sharp frost prevailed, but the air was calm, and the active operations in which the men were engaged kept them in excellent health and spirits.

The first day passed without the slightest mischance. In the

evening, at sunset, a halt was called, and preparations made for a substantial meal before resting for the night. Then Zeno, in the name of the captains, congratulated Sorbolo upon the complete success with which his plans were working. Day after day passed in the same way, without accident of any kind. The passage of the ships caused the greatest excitement among the peasants, who were profoundly impressed with the appearance of the great hulks moving over their fields with as much ease as if they had been a string of carts. In the day time the creaking of the wheels, as they revolved over the frozen surface of the ground, was the only noise caused by the progress of the expedition, and at night the numberless lights and camp-fires, and the occasional tread of the sentinels and patrols, were the only noises to be heard. There was no shouting, no hurrying to and fro, such as usually attends the movements of large bodies of men. All this had been provided for, and the quiet of a well-disciplined camp observed throughout. So long as the level ground lay before them, all went well; but after crossing the small lake, which Sorbolo had spoken of to the Doge and his counselors, and the almost perpendicular sides of Mount Peneda presented themselves, the soldiers looked upon the impediment with consternation, if not dismay. To drag the ships up such a place appeared to them a task of ridiculous absurdity. But Sorbolo's plans had compassed every difficulty. They anchored the fleet at a point where a little mountain stream, like a silver thread, ran in a narrow gully to the lake. The bed of this gully was so small that only two men could walk abreast in it. The path was also obstructed by the growth of lofty pines, and the mountain sides were thickly covered with giant trees. Sorbolo laughed when he saw the blank looks on the countenances of the men. Peasants from the surrounding country had been summoned in large numbers with pick-axes and spades. They were separated into detachments and worked together with the soldiers and mariners, under the direction of captains selected for the task by Zeno and Sorbolo. In the first place, the base of the mountain had to be leveled, because it rose precipitately from the ground. Then the bed of the mountain torrent had to be widened, and finally the galleys and the barques had to be drawn

up the causeway so constructed. No portion of this work daunted the men as soon as they comprehended the plans of their leaders. Hundreds of men with pick-axes soon dislodged the broken ground on the mountain sides in sufficient quantity to fill up the space between the base of the rock and the shore with a sloping causeway, while hundreds of others were employed cutting down the trees in the bed of the little stream and from the sides of the mountain in sufficient quantity to form a continuous causeway one mile in length to the summit of Peneda. All these several operations were accomplished, and after the lapse of a few days preparations were finally made for the experiment. The levels of the roadway were pronounced perfect, and then, by direction of Sorbolo, earth was strewn upon the fallen trees, and snow was shoveled upon it, which, freezing in the night, consolidated the foundation over which it was designed the ships should pass. The oxen were of no use in this work, and they were driven around the small lake and up the mountain paths to the summit, there to await the arrival of the ships. In place of them a large number of windlasses were fixed at regular distances from each other on each side of the roadway. By a proper distribution of the men in the transit of each vessel, the journey up the mountain was performed without any accident. The ropes which were attached to the windlasses and the ships were made for the purpose, under the direction of Sorbolo, in the rope-walks of the Arsenal. As each vessel, mounted upon its carriage, started up the incline, six windlasses were brought to bear at a time: and as the vessel moved upward, foot by foot, it was carefully wedged so that it could not by any mischance slip back again. Then, when each set of windlasses had performed their work, the ropes were carried on and attached to a fresh set of windlasses in advance. In this performance the large vessels gave, as a matter of course, much greater trouble than the barques. But owing to the completeness of the arrangements, and the scientific disposition of the appliances with which Sorbolo had supplied himself, the most difficult portion of the undertaking was carried out with as complete success as the preceding portion of the journey. Sorbolo superintended every step himself. He chose the spots for the windlasses; he directed the width of the causeway and

the slope of the platform; he even determined the length of the ropes which were attached to the ships and the points to which the ropes were to be fastened. The detachments of men who assisted in these operations were drilled in their special work by Sorbolo. Each man knew precisely what he had to do, and when the moment came for action. When the first ship was mounted upon its carriage, and everything was ready for the start, a trumpet sounded, the windlasses slowly revolved, the ropes were strained to their utmost tension, and the galley, trembling from bow to stern, moved forward with a slow and stately pace, as though conscious of the important share of the work it had to perform. Slowly the galley moved up the steep incline, its bows pointing to the clouds as though destined for some voyage above the sky. As the men traveled around the windlasses they sang in chorus their favorite battle-songs, and Zeno, side by side with Sorbolo, stood upon a rocky prominence which overlooked the passage of the vessels, and controlled the movement. At Sorbolo's bidding a trumpet sounded, and the machinery was put in motion; then at a second blast the men ceased, and again at a third blast they resumed their labors and the galley crept up nearer to the summit of the mountain. When the first galley appeared upon the crown of Mount Peneda, the men could not resist a hearty shout of triumph, which was echoed again and again by the sharp rocks, until it died away in a whisper upon the face of the lake below. The course of action pursued by the whole was the same. The small barques gave the men little trouble, and when the whole was finished and the fleet rested triumphantly upon the crest of the mountain, the oxen took their places again and the ships were moved majestically to the mountain side, from whence the soldiers, sailors and peasants could see plainly far below them the clear waters of the lake. Never before or since had such a feat been accomplished, and for the first time in the world's history a fleet of war ships had ascended to the summit of a mountain. The spot chosen for the descent was one where the granite rock had been in antediluvian ages polished by the passage of icebergs down into the lake below; but in the course of ages masses of granite falling from above had broken the face of the decline, and Sorbolo found it necessary

to bring his peasants and soldiers upon the scene, with their pick-axes and spades, in order to make a level road to the ground below. The face of the rock was so precipitous that the workmen found no track or path upon which even a goat could stand. But the work was accomplished in due time—masses of loose granite were dislodged and hurled below, trees were cut down and earth was shoveled upon them, as in the ascent. When all was ready the ships were carefully placed upon the causeway, but the work which the windlass men had now to perform was exactly the reverse of what it was on the other side of the mountain; for whereas it was by their efforts previously that the great ships were drawn up the steeps, now it required their utmost skill to prevent the huge weights from being precipitated to the bottom. But Sorbolo had fitted the windlasses with an appliance which greatly assisted the men. The wheels were taken from under the galleys, and as soon as the wedges were removed and the brakes applied to the windlasses, each ship moved steadily downward, slowly and majestically descending the steep incline, until at the foot of the mountain it glided quietly upon the rollers placed to receive it, and the oxen proceeded with it as before, about twelve miles to the border of the lake.

The abrupt descent was the only portion of the journey attended with misfortune; one ship, overbearing the windlasses, obtained such a momentum as to snap all the ropes asunder, and dashing madly from side to side, fell to pieces on the ground at the bottom. With this exception, the whole flotilla traversed the land and crossed the mountain in safety; and in February, 1439, every ship floated in peaceful triumph in the harbor of Torbolo, on the northeast corner of the lake, three months only having been consumed in the journey.

Zeno now took command, and in order that he might complete his arrangements for a conflict with the enemy, he ordered the haven to be strongly defended by piles, so as to prevent a surprise.

Several weeks elapsed before the Milanese discovered the presence of the Venetian ships. A light barque which had been dispatched from the opposite side of the lake to reconnoitre, first saw the flotilla. The men on the little vessel, when they saw the

towering sides of the great galleys floating in the harbor of Torbolo, could not believe their own senses. They fancied at first that they beheld a mirage of the Milanese fleet which they had just left, and therefore sailed straight on until they came to the mouth of the haven and found it effectually blocked with piles, from which they could distinctly see the Venetian soldiers on the decks of the ships, and the flotilla of light barques anchored around. They were filled with astonishment and awe at what they supposed was a miraculous interposition of Providence, for they were convinced that to no human agency could such a phenomenon be attributed. The Milanese barque hastened back to the fleet and reported to the commanders, Vitaliano and Giovanni Gonzaga, the discovery they had made. The commanders considered the report incredible, but nevertheless ordered another barque to reconnoitre, and upon its return with a confirmation of the news, made immediate preparations to fit their vessels for battle. This, however, occupied many weeks, and in the meantime Zeno, having completed his arrangements, sent out his barques to reconnoitre. In the course of a few weeks more the barques of the opposing commanders met, and encounters took place which most frequently resulted in favor of the Venetians.

Meantime the arrival of a Venetian fleet upon the lake was communicated by spies to the citizens of Brescia. But the news was received with incredulity when the messenger declared that the fleet had crossed the mountain of Peneda, and the man was put into prison until the arrival of a succession of spies confirmed his story. Two serious obstacles, however, still presented themselves before any attempt could be made to relieve the city; one was the fleet of Gonzaga and the other the army of Piccinino, which was encamped between the lake and Brescia. But the presence of the Venetian fleet operated with great fear upon both commanders, and until it was removed very little progress could be made by either the Milanese fleet or army.

The condition of Brescia was at this time very serious. The food which they had was becoming exhausted, and scanty supplies only could be obtained from the surrounding country, owing to the presence of the enemy. Still every week a certain quantity of fresh food was obtained, and this, combined with the

presence of the Venetians in their immediate vicinity, sustained the hopes of the besieged. Dispatches announcing the success of the expedition across the country to the lake were duly received in Venice, and in the beginning of Spring preparations were made for the renewal of the conflict on land. The forces of the allies were slow in assembling together, and it was not until May that all was ready. Then the army moved forward under the direction of Sforza, and in the month of June was engaged in active operations in all the districts lying between Venice and the Tyrolese mountains. The reduction of the fortress of Tenna, then in the possession of the Milanese, was absolutely necessary, and while the army was making the approaches necessary to its investment, the flotilla under Zeno was holding the Milanese in check upon Lake Garda. On the 26th of September he determined to give them battle, and leaving his anchorage at Torbolo, was soon surrounded by the superior forces under Gonzaga and his fleet utterly destroyed. During the conflict, however, hundreds of the Venetians escaped to the shore, and under cover of the darkness succeeded in penetrating to the city of Brescia, taking with them a portion of the stores which they had brought with them.

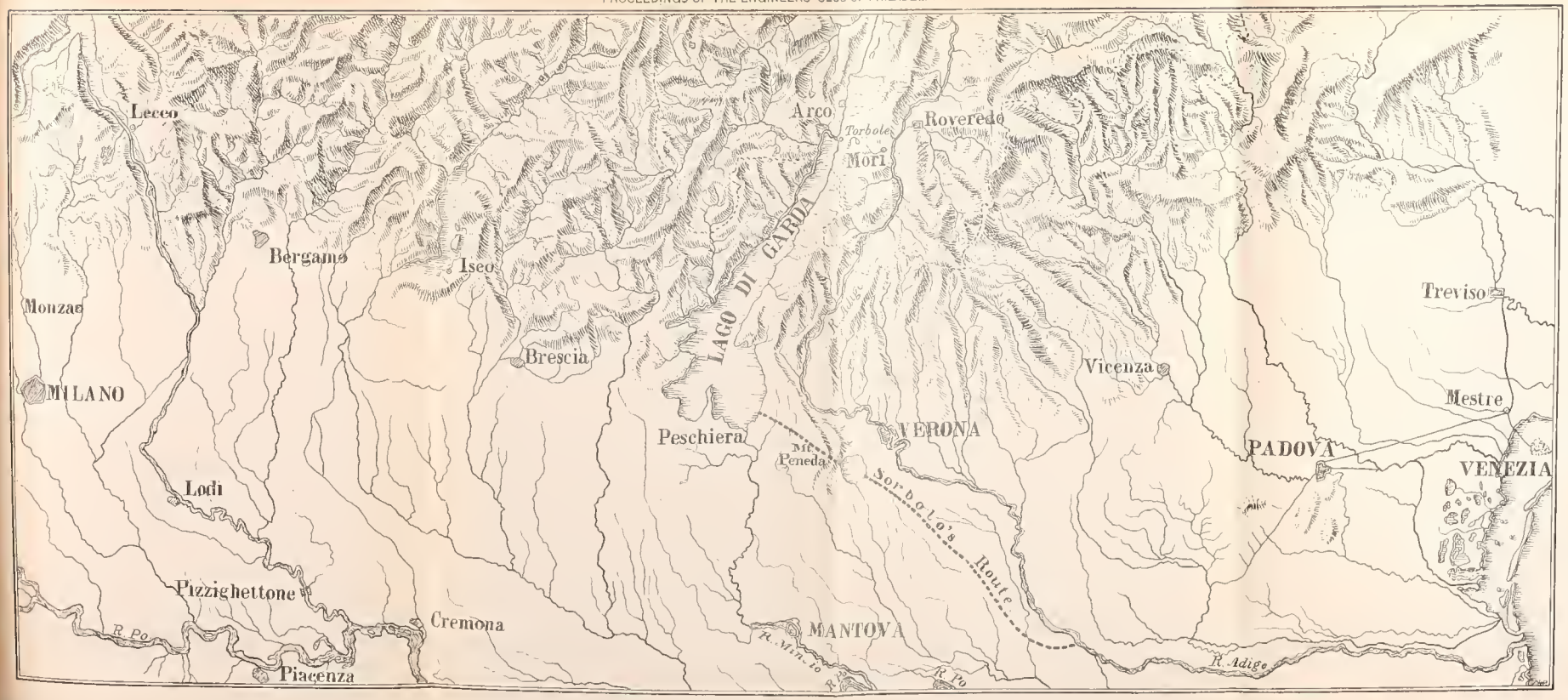
The captured ships were burnt by the Milanese, and thus perished that fleet which had performed a journey unparalleled in the history of the world. The news of the disaster was carried to Venice by Sorbolo and others, and the Senate gave immediate orders for the preparation of another fleet to take its place, which Sorbolo had undertaken a second time to carry across the country and over Peneda to the lake. But the successes of Sforza's troops rendered the immediate repetition of the feat unnecessary. The fleet under Zeno had held in check a large force of the enemy, and its discomfiture now compelled Sforza to redouble his exertions, and in the second week in November he was in sight of the citadel of Tenna, which he immediately invested, dispatching messengers across the mountains to Brescia, informing the garrison of his approach and inviting their co-operation. His messengers found the Brescians reduced to the greatest extremities, but his presence inspired them with new courage, and they were enabled to contribute a contingent, which in the doubtful

crisis of the battle was sufficient to turn the tide of the conflict, the Milanese commander, Piccinino, escaping from the fortress by a trick.

The next morning the allies commenced their operations for the siege of Tenna, and while they were proceeding Sforza contrived to throw supplies into Brescia. These afforded the unfortunate inhabitants very grateful relief. The operations for the siege of the castle were proceeding when news reached the allies that Piccinino had escaped, and by a rapid movement with the remnant of his army had actually got between them and Padua, and obtained possession of the important city of Verona. This compelled Sforza to raise the siege and proceed by rapid marches to the new scene of conflict. He reached the city in time to defeat Piccinino before he had completed his arrangements for his own security, retook Verona, and drove out the whole force that the Milanese had been able to throw into the place. Then returning by a series of rapid marches, reached the passes of Tenna, from whence he dispatched fresh supplies and additional soldiers to the city of Brescia. But he was unable to afford them permanent relief, and throughout the remainder of the winter of 1439 the city suffered many privations.

Meantime Sorbolo had been busy at Venice, and early in the spring of 1440 the Venetians managed to dispatch another fleet, larger and more powerful than the first, to the Lake Garda, under the command of Stefano Contarini. He opened the campaign in April by destroying the fleet of the Milanese, and in the month of June Sforza utterly crushed the army under Piccinino; and Brescia, after sustaining a siege of three years, was permanently relieved.

But it is not the military or strategic success which finally attended these engineering operations of Sorbolo, but the operations themselves, to which we invite attention—the fact that more than four hundred years ago two formidable fleets, fitted out by the leading maritime power of the day, loaded with a complete armament for active aggressive operations, were successfully carried over land and over a formidable mountain barrier, some ninety miles from the waters of the Adriatic to the Lake Garda. Nor was this accomplished by the aid of any of our modern


Leceo
Arco
Torbole
Roveredo
Mori
LAGO DI GARDA
Bergamo
Iseo
Monzas
Brescia
Treviso
MILANO
Vicenza
Mestre
Peschiera
Mt. Peneda
VERONA
PADOVA
VENEZIA
Lodi
Sorbolo's Route
Pizzighettone
Cremona
R. Po
MANTOVA
R. Mincio
R. Po
R. Adige
Piacenza

appliances—there was no carefully graded railway, securely ballasted and bridged, provided with rails of steel and skilfully constructed locomotives. The means at hand were cordage and windlasses, oxen and manual force alone, and the roadway the most primitive imaginable.

It will be seen from the Consul's letter that some of the vessels transported overland were of no inconsiderable size. The displacement of the largest class, as near as can be estimated, was over 300 tons, or a gross register of 175 tons. They were manned by at least 150 sailors, with probably a contingent on board of at least 150 marines.

XXII.

A BOAT-TELEMETER.

By R. Meade Bache, Active Member of the Club.

Read June 18th, 1887.

The device of a boat-telemeter, illustrated by the two photographs which I beg leave to present to the Club, was designed by me, and has been employed by me for several years in surveying such places as cannot be otherwise easily reached.

In general topography it often happens that there are large tracts where, either from instability of ground or rank growth of reeds, only a few stations are possible. Again, there are many shores where the outside line is sedge growing in mud, through which it is not practicable for telemeter-carriers to wade. There are shores in which the detail required along the solid parts is so small as to require only stations along it very far apart, in which case angles taken to flagged withes along the edge of sedge-grass or flat would give very poor determinations. In any of these cases, and many more, this kind of telemeter is most useful.

The graduation of the present telemeter is on a white-pine board of five-eighths of an inch in thickness, reinforced by a backbone of a batten, screwed to the back, and running the whole length of the board, except where it fits into the supporting

stanchion. The stanchion is made of hickory. This stanchion ships into the boat, just as a mast is stepped, except that it is placed vertically, as a mast very rarely is, and must revolve easily in the step in the bottom of the boat. The prongs into which the telemeter fits in the stanchion are of different lengths, the longer one being behind the telemeter, so as to give the telemeter plenty of bearing, and the shorter one in front, so as not to interfere with the view of the graduation of the telemeter. The telemeter is fixed in the prongs of the stanchion with a screw-bolt and nut, and when not in use the parts are separated and stowed snugly in the boat, the telemeter always face downward, so as to save the graduation from injury.

The graduation on the telemeter shown in the photographs represents 300 metres, which can, by "doubling up" with one pair only of the horizontal wires in the telescope used with it, be made to read to 600 metres, with an accuracy up to the platting capacity of the scale of $\frac{1}{10000}$, and for outlines so indeterminate as those of sedge-grass and low flats, with an accuracy sufficiently great up to the scale of $\frac{1}{5000}$.

The graduation of the telemeter is peculiar, and is strictly in accordance with the purpose for which the telemeter has been employed. It would serve no good purpose to graduate every hundred-metre space. A top or a bottom hundred-metre space is all that it is necessary to graduate minutely. In this case it is the top one-hundred-metre space that is graduated. So we have with that, and the two other spaces ungraduated, anything within 100 metres; anything between 100 and 200 metres; and anything between 200 and 300 metres, or, if we are "doubling up," we can go as high as 600 metres. Each of the two lower spaces is subdivided only at the middle, or fifty point: thus affording convenient zero points, if the lower part of the telemeter be shut off by reeds or other obstruction.

If it were attempted to graduate minutely even the one-hundred-metre space, that is graduated to five metres, it would either defeat the object in view of reading more closely than at present, or else it would make the labor of reading slow. The graduation representing one or two metres would, in some conditions of the atmosphere, be undistinguishable. Comparatively few persons

know the capacity of the human eye to divide proportionally. The smallest graduation on this telemeter, to five metres, or, in "doubling up," to ten metres, enables a person using it to read perfectly well within one or two metres. With it lines of between 500 and 600 metres have been frequently tied on to each other, coming out with great accuracy. If, on the contrary, it had been graduated to one or two metres, it would often, at long distances, have been impossible to read it with accuracy. Just opposite to the fiftieth metre, on the uppermost one-hundred-metre space, is a patch of black, to direct the eye to the middle of that space. The general marking of the telemeter is in black, and the marking of the fifty-spaces and the five-spaces, in vermilion.

In one of the photographs the boat is seen in position, on an edge of sedge-grass, with the staff prepared to be read. The operator at the instrument waits, if the wind is not unfavorable to his hearing, until he hears a signal-whistle. He then for the first time looks toward the boat, and takes the distance in an instant, and the sketcher, in the bow of the boat, proceeds with his drawing. Often the chief of a party, while going to work along shore, can make his sketch of such a place, leaving white muslin tags tied to the grass or reeds. Afterward, when he is at a station, the boat can go with the telemeter to the places where the tags have been left.

I have been using this apparatus for several years. Many places on Delaware River and Bay could not have been accurately mapped without it, except through an expenditure of labor and time wholly disproportioned to the importance of the topographical features to be obtained.

XXIII.

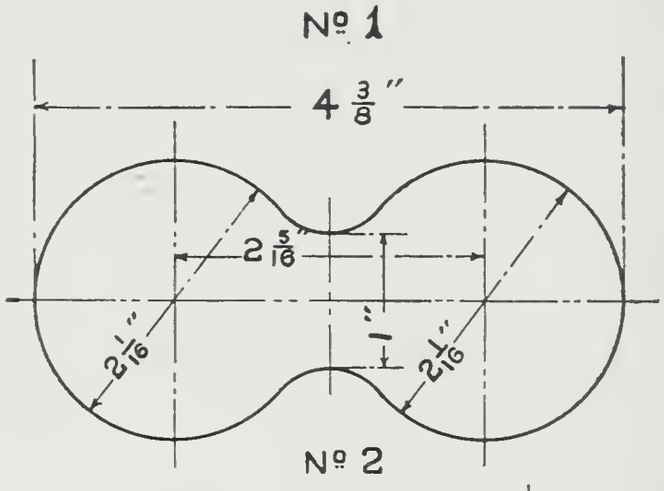
CEMENT TESTS.

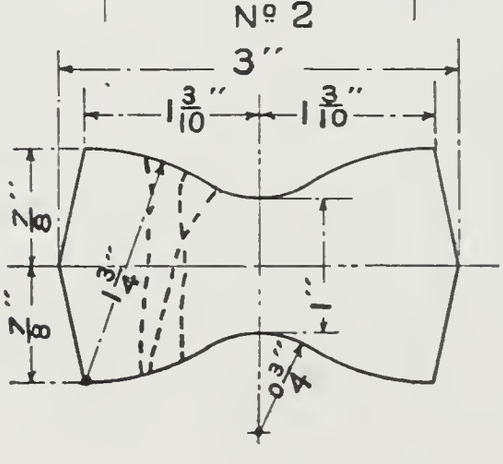
By J. E. Codman, Active Member of the Club.

Read November 19th, 1887.

During the past summer I had under my direction the construction of a long retaining wall, built of rubble masonry, supporting a high bank of earth. The specifications required the mortar to be composed of "Portland cement" and bar sand in the proportion of one of cement to two of sand.

For the purpose of testing the cement I constructed a temporary testing machine consisting of scale beam and box containing sand; this was arranged in such a manner that the sand could be run slowly into an iron box suspended on the scale beam, and a strain brought slowly upon the cement briquette; after the fracture of the briquette the sand was carefully weighed and the weight multiplied by the relative leverage for the tensile strength of the cement. The form of briquette is shown in the accompanying diagram, marked No. 1.





A Fairbanks testing machine was afterwards procured, from which samples of the same cement were tested.

The form of briquette used with this machine is shown on the diagram, marked No. 2.

The following tables show the results obtained from different brands of cement and different forms of briquettes.

It is to be observed that those tests marked "*crushed*" the briquette did not break, but seemed to split, as shown by the dotted line on the diagram. *All of the briquettes were made of pure cement.*

Brand of Cement. Test No. 1.

Saylor's Allentown Portland.

Days old.		Strength per sq. in.	Remarks.
15	Set in water	303	
15	"	264	
10	"	264	
10	"	275	

Brand of Cement. Test No. 2.

Hollick Imported Portland. (English.)

Days old.		Strength per sq. in.	Remarks.
12	Set in water	391	
13	"	402	
12	"	391	
16	"	357	

Brand of Cement. Test No. 3.

Jossen Imported Portland. (English.)

Days old.		Strength per sq. in.	Remarks.
13	Set in water	391	
13	"	479	
12	"	622	
12	"	330	

Brand of Cement. Test No. 4.

Saylor's Allentown Portland.

Days old.		Strength per sq. in.	Remarks.
17	Set in water	332	
18	"	540	
18	"	352	Crushed.
18	"	375	do.
20	"	325	
20	"	268	
20	"	318	
20	"	268	

Brand of Cement. Test No. 5.

Hollick Imported Portland. (English.)

Days old.		Strength per sq. in.	Remarks.
19	Set in water	482	
19	"	440	
18	"	335	
18	"	350	

Brand of Cement. Test No. 6.

Jossen Imported Portland. (English.)

Days old.		Strength per sq. in.	Remarks.
18	Set in water	780	
16	"	—	Crushed.
19	"	500	
19	"	430	Crushed.
16	"	730	
16	"	545	Crushed.
16	"	?	Not broken with 975
16	"	780	pounds pull.
16	"	775	

Tests Nos. 1, 2, 3 were made with the temporary machine and using the briquette shown on the diagram, marked No. 1. Tests Nos. 4, 5, 6 were made on a Fairbanks machine, using the form of briquette shown on the diagram, marked No. 2.

Attention is called to the fact that in using the form of briquette

marked No. 1, a greater proportion of specimens broke at the least cross section, the specimen No. 2 either splitting or breaking above the least cross section. The general results obtained were remarkably good. Attention is also directed to the want of uniformity in the published tests of this kind, the character of the machine upon which the tests are made, the form of briquette, conditions of the test, all of which seem to be according to the individual interests at stake in making them. Much better results for practical use could be obtained if a better system for conducting this class of observation were adopted.

DISCUSSION BY A. MARICHAL.

Among the test pieces presented to the Club by Mr. Codman there is one, he says, which did not break under a pull of nearly 1000 pounds per square inch. Some members, not very well posted on the properties of cement, may suppose that it must be an extra good cement for masonry work; it would be a great mistake, and I dare to say that a cement with lower tensile strength would very likely be much better.

My assertion is not based upon any theory, but upon extensive experiments. During the year 1881, I had to construct a great number of sewers in Belgium, and I made, for my own satisfaction, complete tests of French, English and German cements. I am sorry that at the time I did not think that I should have to-day the pleasure to talk before you on the subject of cements, otherwise I would have kept a record of said tests, and have presented to you some figures which would convince you upon the correctness of my assertion.

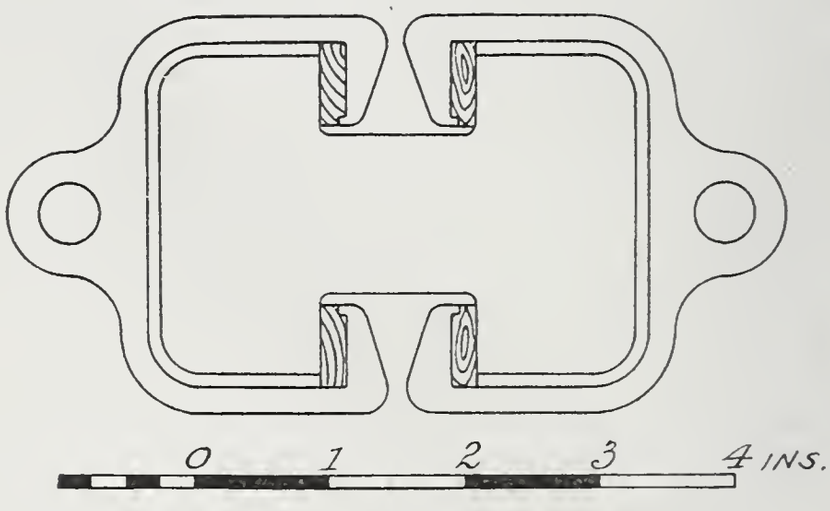
What I am able to say is that a test of pure cement is of no practical value in determining the quality of a cement which has to be mixed with sand when you want to use it. If you desire to know the value of a cement to be used with two or three parts of sand, test it with two or three parts of sand, and you will be able to judge of its merits for the work for which it is intended.

I have tested some French cements ground so fine that it would leave a residuum of only five to eight per cent. in

a sieve of 30,000 meshes per square inch. This cement had comparatively a low tensile strength when tested pure, but had an extraordinary high tensile strength when mixed with two or three parts of sand. On another hand, some English cement ground very coarse would give a very high result when tested pure, and a very low result when tested with sand. I found that generally English cement was coarser than German cement, and that the latter was a very good one to be used in masonry work when it has to be mixed with sand.

There is another point which should not be overlooked when judging of a cement; it is the tendency that said cement has to crack when it contains unslacked lime. A cake should be placed in water immediately after setting, and should be observed daily in order to see whether cracks appear on the edges, in which case the cement would be unfit for immediate use.

Mr. Codman says that most of his test pieces did not break at the smallest section. The shape of test pieces I used, and which is sketched below, did not give me any trouble, and, with very few exceptions, all the pieces were broken at the required places. Test pieces of 16 square centimeters, and nine square centimeters in section, gave practically the same result.



XXIV.

THE PALMETTO RAILROAD.

A LINK IN THE METROPOLITAN LINE.

By P. T. Osborne, Active Member of the Club.

Read December 3d, 1887.

Many efforts have been made to shorten the mileage on the Southern routes, to bring into closer connection the owners of the grand mineral and agricultural regions of the "New South" with their appreciative brethren of the Northern States, who, by the introduction of their capital and business qualifications, have awakened the zeal and energy of the Southern people, which is the sure promise of a glorious future for both North and South, blending all interests together and making a Union that will need no constitutional bond.

The Metropolitan Line.

The Metropolitan Line, the direct route, was long since advocated by Moncure Robinson, Esq., an Honorary Member of this Society.

The Palmetto Railroad.

The Palmetto Railroad, an important link in this line, has been lately completed under Chief Engineer, Wm. Moncure, Esq , from Hamlet to Cheraw, 18¼ miles.

As engineer in charge of this portion I desire to exhibit a skeleton map, showing the 554 miles of this main route, extending from Washington, through Richmond, Petersburg, Raleigh and Columbia to Augusta, Ga., and to call your attention to its directness.

The links unconstructed in this route, in May of last year, were from Petersburg, Va., to Ridgeway, N. C., about 75 miles; from Hamlet, in North Carolina, to Cheraw, in South Carolina, 18 miles, and its extension of 87 miles to Columbia, S. C., making, with 78 miles from Columbia to Augusta, Ga., a total distance of 258 miles to complete this route.

The link from Hamlet to Cheraw was important by reason of the connection made at Hamlet with the Carolina Central, leading to the port of Wilmington, N. C., with the Raleigh and Augusta and its junction lines, the Raleigh and Gaston, and the Seaboard and Roanoke to Portsmouth and Norfolk, opening new markets for cotton and tobacco for large districts that were before chiefly confined to the Charleston market.

At Cheraw, the Palmetto Road, opened in September of this year, connects with the Cheraw and Darlington, 40 miles long, to Florence, where a junction is made with roads to Wilmington, Charleston and Columbia, and with the Cheraw and Salisbury, 25 miles to Wadesboro, on the Carolina Central Railroad. Both these roads running from Cheraw belong to the Atlantic Coast Line system.

Pee Dee Bridge.

The chief feature of this Palmetto road is the bridge that carries it over the Great Pee Dee River, near Cheraw, with an iron superstructure of 614 feet, and piers from 50 to 60 feet in height.

It is a thorough bridge, Pratt truss, and was rapidly and efficiently erected, by the Phœnix Bridge Company, in 50 days.

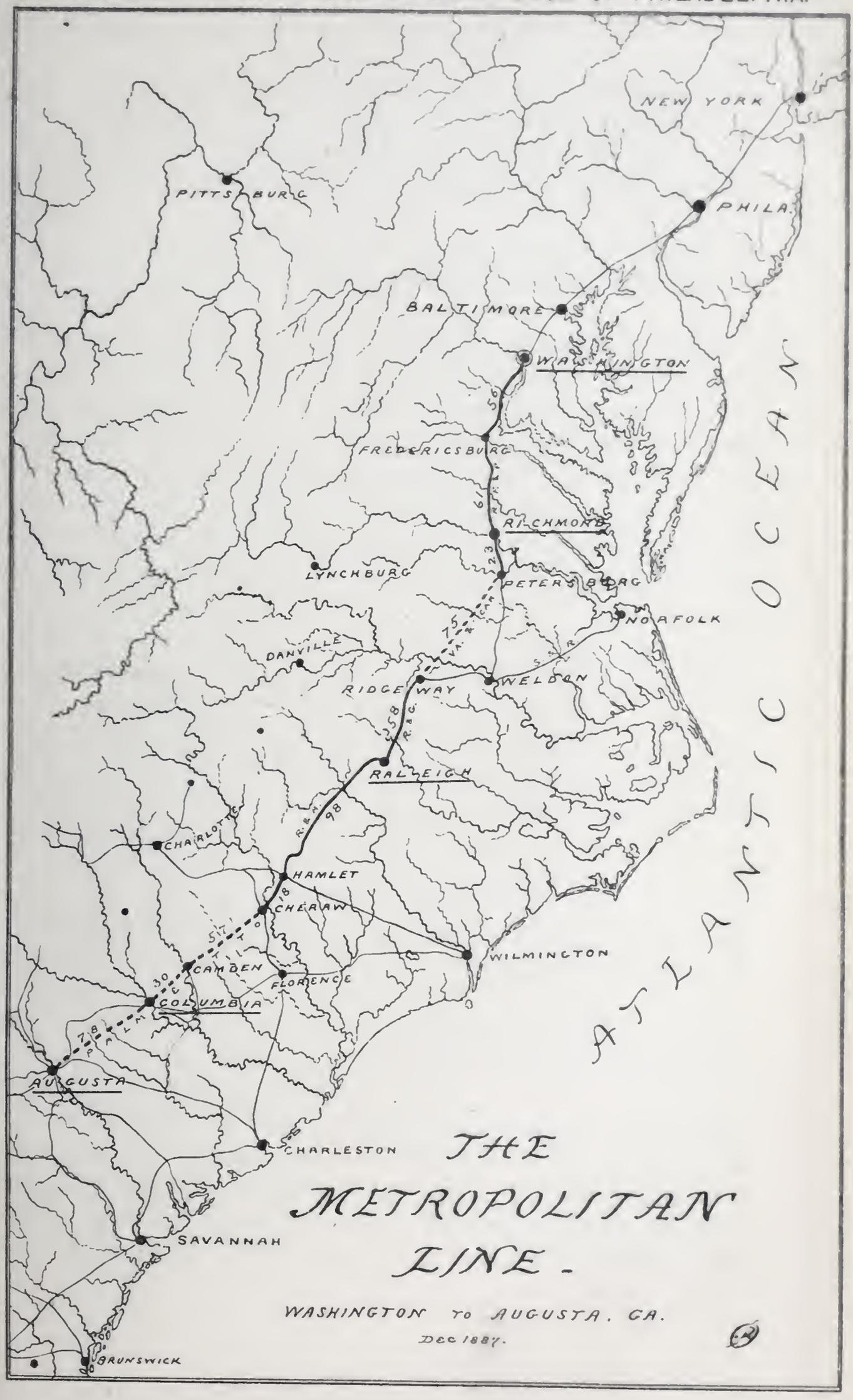
The falseworks, used under one span at a time, contained some 90,000 feet B. M. After the falseworks were in position a span of 150 feet could be erected, without the floor system, in a day and a half, with the assistance of a hoisting engine.

Trestle.

The eastern trestle approach is 2,800 feet long, and the western 1,200, a total of 4,000 feet of trestle work crossing the river bottom lands, which are more or less covered with water during freshets. The height of trestle varies from 10 to 30 ft.

Piers.

The bridge rests upon five granite piers, from 50 to 60 feet high, most of the stone for which was brought 160 miles by rail, from the quarry of P. Linehan & Co., on the Raleigh & Gaston Railroad. It is an excellent quality of granite, splitting readily by wedges into large blocks.


NEW YORK
PITTSBURG
PHILA.
BALTIMORE
WASHINGTON
FREDERICSBURG
RICHMOND
LYNCHBURG
PETERSBURG
NORFOLK
DANVILLE
RIDGEWAY
WELDON
RALEIGH
CHARLOTTE
HAMLET
CHERAW
WILMINGTON
CAMDEN
FLORENCE
COLUMBIA
AUGUSTA
CHARLESTON
SAVANNAH
BRUNSWICK
ATLANTIC OCEAN
THE METROPOLITAN LINE.
WASHINGTON TO AUGUSTA, GA.
DEC 1887.

The contractors for the masonry were Lamkin & Co., in 1884–5, and P. Linehan & Co., who completed the piers this year.

The work was expedited by the use of a wire cable stretched across the river, on which moved a "traveler" to carry stone and cement.

A depth of 37 feet was excavated to reach solid rock foundations for the two shore piers. There are 2,000 cubic yards in the five piers.

The stone was laid in Rosendale cement, in the proportion of one of cement to one of sand for the outside course, and one to two for the interior, which set well and made good bond.

That part of the masonry, built by Linehan & Co., about 1,400 cubic yards, was completed in 12 weeks.

The road itself is well constructed through a sandy soil, fully drained, has 50 pound steel rails of the Cambria Company's make, laid on 2,640 ties per mile, fastened with angle and plain bars, and has the Verona nut-lock.

The sharpest curvature in its main line is four degrees, 72 per cent. of the line being straight. The ruling grade is $52\frac{8}{10}$ feet per mile, undulating.

The completion of this short link, with its important bridge over the Pee Dee River, has created a strong desire in the people throughout the country, from Cheraw to Columbia, to have that extension soon built.

Virginia and Carolina Railroad.

The line between Petersburg and Ridgeway has been already commenced, and is in the hands of gentlemen interested in its completion and able to secure the same.

That part of this route, called the Richmond, Fredericksburg & Potomac, is the most important link between the Northern and Southern Railroad systems.

By reference to the map it will be seen that this route is the direct line from Washington to Augusta, Ga., connecting the capital of the United States with the capitals of Virginia, North Carolina and South Carolina and at Augusta, making junction with lines running to the most important cities of the far South.

XXV.

THE UNACCOUNTABLE DEFICIENCY IN THE TRACK OF AMERICAN RAILWAYS.

By R. B. Osborne, Active Member of the Club.

Read December 3d, 1887.

Every engineer, civil or mechanical, in this country is aware of the facts which I desire briefly to allude to in this paper. It seems unaccountable then that the utilitarian and inventive genius of the American people should not have deduced from these facts the necessity of improvement, and that the constructors and operators of our railroads should be willing to go on in the same old rut, seemingly oblivious that the efficiency of our locomotives and other rolling stock is kept thereby from the full exercise of their powers, and that profits are from the same cause diminished.

The subject which has called forth these remarks, and which I desire now to submit to the members of this Society, is the persistent use, in the United States, of the old hook-headed spike to fasten the rails to the cross-ties.

For many years my individual efforts have been directed to the advocacy of a departure from this practice, so far, at least, as the roads with which I was connected were concerned; but all these efforts were frustrated by the impatience of directors to get their lines opened for traffic, and by the unwillingness of manufacturers to countenance any change that would necessitate the alteration of their established plant.

The old hook-headed spike is an abortive, unmechanical and too temporary expedient, unsuitable for use on what purports to be finished and permanent work. Driven by heavy hammers into the cross-ties it crushes the timber, and leaves around it a crippled fibre of wood, which water will follow, producing interior decay. These spikes do not permanently fasten the rails to the cross-ties.

Walk over any of our railroad tracks and you will find many of the spike-heads from $\frac{1}{16}$ to $\frac{3}{8}$ of an inch above the bases of the rails; this, of course, is proportioned to the incompleteness of the supporting ballast, caused much by its unequal depression into

the softer material underneath. As the spaces between the rail and spike-heads increase, the hammer is again applied to drive the spikes home, but their hold in the timber is *less* than it was at first, and each succeeding time they lose more of their power as a fastener.

These spaces, caused by the drawing of the spikes, are the measures of the rise and fall of the rails on the cross-ties, under the action of the trains, and are injurious in proportion to the speed and weight of trains. It is this injury, and not decay, that on roads of very heavy tonnage puts a limit to the life of the cross-ties.

These spaces, too, are the cause of the rattle and noise to which we are so much accustomed that it does not attract our attention much, but which foreign visitors always notice. It is new to them, because the law of England, and I believe of other European countries, forbids the use of these fastenings, except for temporary tracks on contractors' work.

The track of a railroad is a part of the mechanism that constitutes a railroad, and a most important part too. Any deficiency in *it* detracts from the efficiency of its rolling stock, and produces "wear and tear" on the whole machine.

What is the remedy? Others have been taught by experience how to solve the problem. Shall not we learn from it also?

The simple cure of all the evil is to lock the *tie* and *rail* together, and hence this fastening, which I now submit to you, has been named the "Tie Lock," as a fit and distinguishing title. It is covered by no patent, and is submitted to the profession for suggestions in its minor details that may make it more perfect. The proposer is in no way interested in its manufacture or adoption beyond a desire to see it proved, believing that it will be found most beneficial to our railroads.

Since our Centennial celebration and the reciprocal communication produced by it between the two countries, America has willingly learned some good lessons from Old England. Is it not unaccountable that her experience in railroad track, in this particular, should have been totally disregarded by us?

England has received a very full return for all we have learned from her, from the introduction of very many of our American improvements.

The efforts requisite to overcome the national prejudice of the English against anything emanating from outsiders, has gradually given way before the inventive genius of America, always progressive and utilitarian. We have no space to enumerate the great number of our improvements which we have sent to our European friends.

From the steam-winged messengers that draw their trains 3,000 miles across our continent; from our palace cars that make long travel a pleasure, and locomotion a recreation and rest; from our American bridges that throw their light, strong and economical spans across our wide streams, and from our extended roofs, that with graceful sweep cover the large areas of our railroad depots, down the long list of inventions, even to the uniform, choice and convenient hardware used in the erection of our dwellings, all have been recognized or adopted by the good people of England and most of the other countries of the old world. We have paid our debt to England for all we have learned from her with compound interest.

The English plan of fastening the rails to the cross-ties consists of bolts that pass through the base of the rails (of similar pattern to ours), and through the tie, secured by nuts under its base, which have on the corners that are next to the tie little projections which, pressed into the timber, prevent any revolution of the nut. The bolt is screwed from the surface above, and the nut can easily thus be kept in close contact with the solid timber of the tie, as its base softens by decay. This effectually prevents the rail from separating from the tie, and if there should occur a lifting or depression, both, as one body, are subject to the same simultaneously.

The English, as you are aware, use also the double-headed rail, with heavy cast iron chairs on each tie, and fastened with wooden wedges and treenails. This system is a greater error, and still more unaccountable, than our persistent use of the old hook-headed spike.

I submit a drawing of the English fastening modified to suit the requirements of our rails. I have endeavored for many years to have it adopted on the roads I have constructed, but an individual opinion seemed unable to prevail against prejudice.

This fastening, you will observe, needs no opening in the base of the rail, but by a hooked-head terminating in an oblong, the bolt can be operated from the track surface. The ties are bored by machinery to receive the bolts, which insures an accurate gauge of track, the nuts can be put in place before the ties are laid, and the bolts be screwed down by a wrench from above. These fastenings are easily removed for necessary repairs, and are not subject to waste and breakage like the spike, and they go back without force into their positions. These bolts of half-inch round iron will be 40 per cent. heavier than the usual $5\frac{1}{2}$ inch by $\frac{9}{16}$ hook-headed spike. A thread of sixteen to the inch, and well defined, is recommended, extending up some $3\frac{3}{4}$ inches from the end.

A railroad with such a track fastening, it is believed, would reach that state of perfection which the superior superstructure of hard wood ties renders possible. It would add greatly to the comfort of the traveling public, and largely decrease annual expenses.

I respectfully submit this matter to the President and members of the Engineers' Club of Philadelphia, suggesting that their endorsement of the facts and views generally herein contained, coupled with an official authority to our worthy Secretary to lay it before the other societies of engineers of this country, would open the way to a full discussion of the subject, which, it is hoped, would result in such an unanimity of professional opinion thereon, that our railroads would ultimately be afforded the benefit of an improved track fastening.

XXVI.

BOILER SPECIFICATIONS.

By C. G. Darrach, Active Member of the Club.

Read November 5th, 1887.

In the present age, when steam is such an important factor in manufactures, as well as in producing the comforts, and I might

say, the necessities of civilized life, no doubt every one of our profession, practicing as an engineer or architect, has been called upon by his clients to make specifications and superintend the erection of steam plants.

Like all other specialities there are numerous forms of boilers in the market, the best of which are, as a rule, protected by patents. The engineer or architect, as a rule, decides upon one of the old forms of boiler, or adopts that patented form which, in his judgment, he considers the best. If the former selection is made, the client does not always receive the best that can be produced; and if the latter, all parties except the patentee are debarred from bidding upon the work.

Each patentee claims that his boiler is the best, and as a general rule, the boiler that is accepted is accepted upon its reputation, or upon the consideration of price. Scientific and practical boiler tests, compelling the builder to come up to the letter of his promises, are rarely made, and, unfortunately, the economy of the boiler is not, as a general rule, considered as a factor in the equation of the bids. That it should be is hardly necessary for me to say, since a difference of ten per cent. in the economy of the boiler will generally cover the interest on first cost.

In order to bring this matter before the Club, and to get your criticisms upon it, following you will find a general specification for boilers which requires the bidder to state, not only the price for the entire work, including boiler, setting, fixtures, etc., but also the economy and capacity that he will guarantee.

The specifications state the minimum amount of water to be evaporated, and require that the contractor will make good his promises. In my judgment, the purchaser as well as the manufacturer of the boiler is thoroughly protected by the specifications.

It is evident to all of you that to make an intelligent comparison of the value of various steam plants, and to fully understand which is the most advantageous bid, the price of the plant must include the cost of everything, from the feed-water to the blow-off and to the steam outlet, as well as everything from the furnace door to the top of the stack; and in making an equation of the bids the economy of the boiler must be considered.

SPECIFICATIONS

FOR

_____ BOILERS, ETC., ETC.,

AT

_____

The contract must include furnishing and setting the boilers ready for use, the main flue from boiler to stack, _____

_____

_____

_____

It must also include one injector, feed pumps, such pipes, valves and fixtures as are herein specified, and a full and complete set of firing tools.

Bidders must be practical and responsible boiler builders, and will be required to give satisfactory security to the full amount of the contract for the faithful performance of the work.

All materials and workmanship, and the fixtures, must be of the best of their respective kinds, and will be subjected to such test as the engineers and architects may decide.

Bidders will be required to furnish with their proposal detailed figured plans for boilers, settings, flues, pumps, general arrangement, etc., etc., including working drawings of boilers, setting and foundations, _____

_____

also specifications which must include the following items:

General description of boiler and accompaniments.

Kind and quality of the material to be used in the various parts of boilers and settings, and _____

Evaporative economy—pounds of water evaporated per pound of combustible, from and at 212 degrees Fahrenheit, burning anthracite pea coal.

Capacity of each boiler—pounds of water evaporated per hour into dry steam, from and at 212 degrees Fahrenheit, burning anthracite pea coal.

Grate surface, each boiler—square foot.
Heating surface, each boiler, "
" in tubes, "
" in shell, "
" in fire box, "
Steam space, each boiler, cubic feet.
Size and full description of heater.
" " " " feed pumps.
" " " " injectors.
" " " " stack required.

General Description.

The boilers and fixtures must stand a safe working pressure of not less than _____ pounds per square inch.

Each boiler must be capable of evaporating not less than _____ pounds of water per hour from and at 212 degrees Fahrenheit, using anthracite pea coal, the gases being delivered to the stack as shown on drawing No.

Boiler Setting.

The brickwork of the boiler setting must be of the best quality straight hard brick, properly laid with headers when required.

The top of the boilers must be covered with a horizontal pavement of best paving brick, or concrete, and the exposed portions of the walls laid with straight hard brick, _____

_____

The front, back, side and partition walls, and the covering of the boilers, as well as the side walls and covering of the main flue, must be built with air spaces at least one and one-half inches wide, to prevent radiation of heat.

The boiler chamber of internally fired boilers must be lined with good quality fire brick.

The boiler chamber of externally fired boilers must be lined throughout with the best quality fire brick, well bonded into the side walls, and no cut bricks will be allowed in the furnaces.

Bridge walls must be built of fire brick tiles.

The fire brick must be laid with fire clay and grit.

The combustion chamber and flues for the passage of gases must be large.

Each boiler must be provided with appropriate cleaning doors, man-holes, etc., and so arranged as to be readily cleaned or repaired.

Externally fired boilers must be provided with full cast iron fronts, fire and ash doors.

Cylindrical boilers must be best quality steel, the lower sheet of externally fired cylindrical boilers must be without seams, and must extend beyond the front head to the cast iron front.

Sectional boilers must be provided with ample steam drum to prevent priming.

Quality of Material to be Used in Boilers.

All steel plates used in constructing the boilers must be made of homogeneous open hearth steel, stamped, showing brand of steel, name of makers, and must be of not more than sixty thousand pounds, nor less than fifty-five thousand pounds tensile strength per square inch, and have an elastic limit of not less than thirty thousand pounds per square inch.

The test pieces under tension must show an elongation of not less than twenty per cent. in a length of twelve diameters, with a reduction of area of not less than thirty-five per cent.

In determining the ductility, the elongation shall be measured after breaking on an original length of twelve times the shortest dimension of the test piece, which must include the curve of the reduction on both sides of the point of fracture. The steel plate must be free from flaws and cracks, and must have a workmanlike finish. The test pieces must bend cold, without crack or flaw, one hundred and eighty degrees to a curve having a radius equal to half its thickness. Rivet steel shall have an elongation of twenty-five per cent. in twelve diameters, with a reduction of area at point of fracture of forty-five per cent., and be capable of bending double flat, without sign of fracture on the convex surface of the bend.

A variation in cross-section or weight of plates, of more than

two and one-half per cent. from that specified, may be cause for rejection.

All bent, corrugated and flanged members must be properly annealed.

The contractor must furnish test pieces of steel, made from coupons on the plates. The coupons must be removed and prepared for testing in the presence of the authorized agent of the

---

Rivet holes shall be so accurately spaced, that when the members are brought into position the holes shall be truly opposite before rivets are driven. The use of drift pins will not be allowed. If rivet holes are punched, the plates after punching must be annealed, otherwise the rivet holes must be drilled or reamed.

Rivets should be driven either by hand or hydraulic riveter. Steel rivets must not be riveted by hand. In the parts of the boiler where machine riveting cannot be done, the rivets must be best quality iron. Rivets must completely fill the holes, and have full heads of a height not less than six-tenths the diameter of the rivet, and countersunk when required.

In constructing the boilers the stamps must be in such a position as to be easily seen on inspection.

The edges of all plates must be planed, and all seams must be fullered both inside and out.

All the flues must be built air tight and protected from moisture, and so arranged as to be easily cleaned.

Each boiler must be provided with a balanced damper, to be regulated by hand and by steam damper regulator, if directed, arranged to work independently, and all the necessary fixtures for its successful operation.

The main flue must be provided with a balanced damper, to be regulated by hand, and by a steam damper regulator, etc., etc., if so directed.

Each boiler must be provided with one main steam valve, two safety valves, steam gauge, water column with cocks and gauge glasses, three tri-cocks, feed pipes, check valves, surface and blow-off pipes and valves.

The steam outlet from each boiler must be connected by curved copper pipe to a steam main and controlled by stop-valve.

Each boiler must be provided with an asbestos packed blow-off plug cock.

The blow-off from each boiler must be carried to a main blow-off pipe terminating _____

_____

Provide two duplex feed pumps with the necessary valves, pipes and fixtures, to pump water at 210 degrees Fahrenheit, from the hot-well, or heater, to the boilers.

Each feed pump must have a capacity of pumping not less than _____ thousand pounds of water per hour, with fifty strokes per minute of one plunger, and must be so arranged to pump either from a hot-well or from a cold water supply to the boilers, or to pump cold water to water service of buildings.

Make all steam and exhaust connections.

Provide one injector capable of discharging _____ pounds of water per hour; make the necessary steam and water connections.

Steam Pipes, etc.

All steam and exhaust pipes mentioned in these specifications must be covered, to prevent the radiation of heat, to the entire satisfaction of the engineers and architects.

Furnish pipes and valves as follows:

_____

_____

_____

_____

Alterations.

It is understood that the engineers and architects shall have the right to make any alterations, additions or omissions of work or materials herein specified or shown on the drawings, during the progress of the work, that they may find to be necessary, and

the same shall be acceded to by the contractor, and carried into effect without in any way violating or vitiating the contract. If any such changes are made, the value of the same shall be decided by the engineers and architects who shall make an equitable allowance therefor, and shall add the amount of said allowance to or deduct it from the contract price, according as the cost of the work has been increased or lessened.

Also that no extra work or materials will be paid for unless ordered by the engineers and architects.

Also that any disagreement or difference between the parties to the contract upon any matter or thing arising from these specifications or the drawings to which they refer, or the kind or quality of the work required thereby, shall be decided by the engineers and architects, whose decision and interpretation of the same shall be considered final, conclusive and binding.

Care of Finished Work.

Particular care must be taken by the contractor of all the finished work, which work must be covered up and thoroughly protected from injury or defacement during its erection and completion.

Removal of Rubbish, etc.

All refuse material and rubbish that may accumulate during the progress of the work is to be removed from time to time as may be directed by the engineers and architects, and on the completion of the work the building, streets and grounds must be thoroughly cleaned up and the surplus material and rubbish removed.

Risks, Blame, etc.

The contractor is to assume all risk and bear any loss occasioned by neglect or accident during the progress of the work, until the same shall have been completed and accepted by the engineers and architects. The contractor is also to assume all blame or loss by reason of neglect or violation of city or other ordinances, encroachments upon neighbors, loss by fire or from any other cause.

The contractor is to properly protect the pavement, floors and buildings during the progress of the work, and make good any injuries that may have occurred in consequence of the erection of this work or during its progression, and must pay for all permits, inspectors fees or any other charges from city or county officers.

The engineers and architects shall have full power at any time during the progress of the work to reject any materials they may deem unsuitable for the purposes for which they are intended, or which are not in strict conformity with the spirit of these specifications. They shall also have the power to cause any inferior or unsafe work to be taken down and altered at the cost of the contractor.

Test, etc.

The boilers, settings, etc., etc., must be completed, ready for use, to stand a working steam pressure of at least _____ pounds per square inch, and the boilers, pipes and fixtures must be tested by hydraulic pressure to at least _____ pounds per square inch, and all local rules and ordinances affecting the same conformed to; the boilers will then be tested for capacity and economy, as directed by the engineers and architects, the expense of which tests, except the cost of coal, must be borne by the contractor, which cost will be deducted from the contract price.

Penalties.

In the event of the boilers not being completed within the time specified, there shall be deducted from the contract price the sum of _____ dollars for each and every legal working day after the specified time during which the boilers shall remain uncompleted, which sum of _____ dollars per day shall be considered as the liquidated damages agreed upon for any failure to complete the work within the time named.

If the boilers do not develop the evaporative capacity named in the proposal, there will be deducted from the total contract price a sum of money proportional to the loss of capacity, and should the boilers not develop the minimum capacity named in

these specifications, to wit: _____ thousand pounds of water evaporated per hour, the contractor will receive no payment for them. In the event of the above mentioned contingency, the boilers must be allowed to remain in use until other boilers can be obtained to take their place, after which time the boilers must be removed, and any and all additional expense incurred in procuring boilers of the proposed capacity will be paid from the security for the faithful performance of the contract.

If the boilers do not develop the economy mentioned in the proposal, there will be deducted from the contract price a sum of money, the interest of which at _____ per cent. per annum would represent the cost of the additional coal required to evaporate the specified amount of steam, to wit: _____ pounds of water per hour from and at 212 degrees Fahrenheit, for _____ hours per day, and during _____ days in a year, the price of coal, containing eighty-four per cent. of combustible, being taken at _____ per ton of 2,240 pounds.

The boilers must be completed and in running order prior to

The contractor must guarantee and keep the boilers and accompaniments in perfect running order for one year after they have been put in operation, provided the owners give the boilers proper care and attention.

Conditions, Requirements, etc.

The material, design and workmanship must be of the best, and must be so arranged as to fulfil the following requirements:

1st. The production of DRY STEAM by economical consumption of coal, with safety and durability of the various parts of the work.

2d. The prevention of discomfort and loss by the radiation of heat.

3d. The most advantageous arrangement for the successful and economical operation and maintenance of the entire plant, cost of repairs to furnaces, boilers, etc.

In awarding the contract, the following points will be considered:

The first cost of the boilers and their accompaniments from the fire doors, to and including the stack, and from the water supply to the blow-off outlet, and to the steam outlet, as well as the relative cost of boiler room required.

Also, the commercial value of the economy guaranteed and relative cost of repairs.

Payments will be made when the work shall have been completed and accepted, as follows:

_____

_____

_____

The contract must be consistent with the requirements of

_____

The contract shall not be sub-let, assigned or transferred to any person or persons whomsoever, without the written consent of the engineers and architects.

Plans can be seen and information obtained at the office of

_____

_____

Bids are to be for the entire work complete. The right is reserved to reject any or all bids.

For the information of bidders, the following facts are noted:

_____

_____

_____

_____

_____

DISCUSSION

By John E. Codman.

Read November 5th, 1887.

In the discussion of the paper entitled *Boiler Specifications*, I earnestly suggest that the paper be discussed in the spirit it is represented as being offered in, keeping always in view the principal and main object of any boiler specification, namely, the unit of measurement of boiler power and the method to be pursued in obtaining it. I believe it impossible to adopt a regular form of boiler specification that will apply to all cases, the preparation of which should be the duty of the consulting engineer, but I do believe a unit of measurement can be adopted that will be an advantage, both to the purchaser and to the manufacturer, and a protection to both. The term horse-power, as at present used, cannot properly be applied to a boiler, although a certain quantity of water evaporated per hour can be termed a horse-power. A committee of the Mechanical Engineers' Society presented an excellent form of boiler test, also a unit of measurement, to be termed a horse-power, but as the report was never finally adopted by the Society, it has been left for the engineering public to adopt or reject it as seemed best.

The unit of $34\frac{1}{2}$ pounds of water per hour from and at 212 F. is about $\frac{1}{3}$ more than the average high pressure engine as constructed to-day requires, but this excess of power is an advantage rather than a loss to the boiler user.

In these specifications, passing over the minor details, and taking the clause on evaporation and that on capacity, the question is narrowed down to a limit of what constitutes boiler capacity. Any manufacturer will readily concede that at the present time he can guarantee to produce a certain number of pounds of dry steam from a given form of boiler, with as much certainty as the engine builder does in presenting his engine to accomplish a certain quantity of work in a given time. Various attempts to agree upon a standard unit of measurement have, from time to time, been presented, but with no universal agreement.

The centennial unit, 30 pounds of steam per hour, from a temperature of 100 F. to steam of 70 pounds gauge pressure, is very nearly the same as 34½ pounds from and at 212 F. With this unit of measurement the boiler power can readily be obtained in terms of horse-power (so-called)—and utilized through the engine. The manufacturers of boilers agree to give a certain number of pounds of dry steam per hour, with a certain number of pounds of fuel, and a specified degree of economy, whether the fuel shall be coal, gas, wood, tan-bark or saw-mill refuse, an equivalent in all cases to be agreed upon by both parties before the specifications are adopted. Failure, in any form, to accomplish the agreed upon results will incur the penalties attached to the specifications.

It seems a part of the consulting engineer's duty to attach to the specifications such other provisions as the circumstances require, but the principal point is to obtain a unit of measurement of boiler evaporation that shall be recognized as legal and binding upon both manufacturer and purchaser. Let our discussion be mainly directed to bringing about a standard unit of measurement to be used in connection with a standard method of boiler test.

The following form is the one submitted by a committee of the "Mechanical Engineers' Society." Some slight additions and changes are made, as suggested from time to time, in reporting the results of some forty or more boiler tests. It will commend itself for simplicity and accuracy, and it is in such a shape that any person connected with mechanical pursuits can easily understand from it the unit of measurement of boiler power and the method to be pursued in obtaining it.

1	RESULTS OF THE TRIALS OF A				
2	Boiler at				
3	To Determine				
4	Date of trial				
5	Duration of trial				
	DIMENSIONS AND PROPORTIONS.				
6	Type of Boiler				
7	Number in use				
8	Diameter of Boiler				
9	Length of Boiler				
10	Numbers of Furnaces				
11	Type of Furnaces				
12	Diameter of Furnace				
13	Length of Furnace				
14	Number of Tubes in each Boiler				
15	Diameter of Tubes				
16	Length of Tubes				
17	Diameter of Drum				
18	Length of Drum				
19	Heating Surface in one Boiler:				
	a Heating Surface of Furnace				
	b Back Box				
	c Combustion Chamber				
	d Tubes				
	e Front of Boiler				
	f Side and Back				
20	Total Heating Surface in Boiler				
21	Total Tube Cross Section Area				
22	Ratio of Tube Cross Section to Grate Surface				
23	Height of Stack				
24	Area of Stack at Base				
25	Grate Surface Wide Long Area				
26	Water Heating Surface				
27	Superheating Surface				
28	Ratio of Water Heating Surface to Grate Surface				
	AVERAGE PRESSURES.				
29	Steam Pressure in Boiler by Gauge				
30	Absolute Steam Pressure				
31	Atmospheric Pressure per Barometer				
32	Force of Draught in Inches of Water				
	AVERAGE TEMPERATURES.				
33	Of External Air				
34	Of Fire Room				
35	Of Steam				

36	Of Escaping Gases				
37	Of Feed Water				
	FUEL.				
38	Kind of Coal				
39	Total Amount of Coal Consumed				
40	Moisture in Coal				
41	Dry Coal Consumed				
42	Total Refuse (Dry Waste in Pounds)				
43	Per Cent. of Refuse				
44	Total Combustible (Dry Weight of Coal, Less Refuse)				
45	Dry Coal Consumed per Hour				
46	Combustible Consumed per Hour				
	RESULTS OF ANEMOMETER READINGS.				
47	Cubic Feet of Air per Hour				
48	Cubic Feet of Air per Hour, per Square Foot of Grate				
49	Pounds of Air per Pound of Coal				
50	Pounds of Air per Pound of Combustible				
	RESULTS OF CALORIMETRIC TESTS.				
51	Quality of Steam, Dry Steam being taken as Unity				
52	Percentage of Moisture in Steam				
53	No. of Degrees Superheated				
54	Factor of Evaporation				
	WATER.				
55	Total Weight of Water Pumped into Boiler and apparently Evaporated				
56	Water actually Evaporated, Corrected for Quality of Steam and Surface Water				
57	Equivalent Water Evaporated into Dry Steam from and at 212° F.				
58	Equivalent Total Heat derived from Fuel in British Thermal Units				
59	Percentage of Heat lost by Radiation, on a basis of 14500 B. T. U. per Pound of Combustible				
60	Equivalent Water Evaporated into Dry Steam from and at 212° F. per Hour				
	ECONOMIC EVAPORATION.				
61	Water Actually Evaporated per Pound of Dry Coal from actual Pressure and Temperature				
62	Equivalent Water Evaporated per Pound of Dry Coal from and at 212° F.				
63	Equivalent Water Evaporated per Pound of Combustible from and at 212° F.				

	Commercial Evaporation.				
64	Equivalent Water Evaporated per Pound of Dry Coal, with One-sixth Refuse, at 70 Pounds Gauge Pressure, from Temperature of 100° F.=Item 63 x 0.7249				
	Rate of Combustion.				
65	Dry Coal actually Burned per Square Foot of Grate Surface per Hour				
66	Consumption of Dry Coal per Hour, Coal assumed with One-Sixth Refuse	Per Square Foot of Grate Surface			
67		Per Square Foot of Water Heating Surface			
68		Per Square Foot of Least Area for Draught			
	Rate of Evaporation.				
69	Water Evaporated from and at 212° F. per Square Foot of Heating Surface per Hour				
70	Water Evaporated per Hour from Temperature of 100° F. into Steam of 70 lbs. Gauge Pressure =Item 60 x 0.8698	Per Square Foot of Grate Surface			
71		Per Square Foot of Water Heating Surface			
72		Per Square Foot of Least Area for Draught			
	Commercial Horse-Power.				
73	On a Basis of Thirty Pounds of Water per Hour Evaporated from Temperature of 100° F. into Steam of 70 Pounds Gauge Pressure (=34½ lbs. from and at 212° F.)				
74	Horse-Power, Builders' Rating at 10 Square Feet per Horse-Power for Fire Surface, 12 Square Feet on ⅔ Surface of Flue and Drum, and 15 Square Feet on ⅔ Surface of Tubes				
75	Per Cent. Developed Above Rating				
76	Per Cent. Developed Below Rating				

DISCUSSION.

By John T. Boyd.

Read November 19th, 1887.

The statement made, that the best boilers in use are protected by patents, is hardly correct; inasmuch as for efficiency some of the marine boilers which are not patented, the writer is creditably informed, have proved equal, if not slightly better, than any patented boiler offered up to the present time.

In the matter of detail, it seems as if more than one feed pump, where one injector is specified, would be superfluous and involve an outlay hardly warrantable at present, owing to facility of obtaining duplicate parts for the many good forms of boiler feed pumps now in the market.

That Bidders shall be required to furnish with their proposals, detailed figured plans for boiler, settings, flues, pump, etc., including working drawings of the boiler, settings and foundations, is a requirement with which very few Builders would be willing to comply; as the writer's personal experience goes to prove that such detailed information has been given to competitors offering lower bids to the injury of the party bidding in good faith, whose plant, from its general excellence, both in arrangement and in detail, warrants a greater price. If all Architects and Engineers were thoroughly practical men there would be no great harm in giving such details, as in the vast majority of cases the same details would be familiar to them; but as few Architects are so informed on these minor details, which go to make up a successful plant, they are frequently appropriated as *their* plan, which, to characterize it mildly, is not honest.

Evaporative economy is largely controlled by the location of the plant, which from its position is liable to have "down draft" in the chimney, and at the different seasons in the year have different effective draft; which in a bad season would militate against a successful evaporative test, and in a better season might pass beyond the stated requirements. While it may be well to specify the fuel to be used during the test, it seems as though

anthracite pea coal is not the most favorable for obtaining high evaporative duty, even when reduced to combustible, as from a sample of coal submitted to prominent boiler builders in this City, out of a total weight of 27½ pounds of supposed good pea coal, 9 pounds were slate, 11 pounds slated coal and the balance dust and coal combined. The capacity of evaporating depends very largely on the fireman, as is well known by every one who has charge of a steam plant, to say nothing of the economy; the coal may be of the best, and the boilers set and located under the most favorable conditions, yet an inefficient fireman would not make them perform as well as one who is more fortunate in his ability to attend properly to the boilers.

It is not always possible to use air spaces of any width at *all* times, because the majority of buildings are put up without much regard to the space which should be properly allotted to the boiler plant; and hence it becomes necessary to arrange the brick settings to conform with the room at disposal, and if insisted on in this case would cut out at least one boiler from a plant.

The specifications should state whether the horizontal pavement, if any, on top of boilers is to be supported by wrought or cast iron bars. While the former will support the pavement and the weight of a man, they are much more liable to be destroyed by the gases than the cast iron bars, the latter being necessarily heavier and costing more to accomplish the same results, but at the same time are almost permanent.

The minimum size of cleaning doors and man-holes should be specified, because there are many boilers erected to-day in which neither of these two details are of convenient size for the purpose intended; the former frequently not even admitting a bucket to be passed through, when removing the dirt from the inside after having been collected there.

The requirement that externally fired cylindrical boilers be without curvilinear seams on the lower sheet is made possible by the modern construction of steel plants and boiler makers' tools, and offers a longer life to a hard worked boiler than where circumferential seams are brought in contact with fire passing over a badly constructed bridge wall, or where forced draft is used.

The test specified for material can be met in some makes of

steel only, and would cut out altogether some material which would be sufficiently good for certain parts of boilers.

The requirement that the steel plates after punching should be annealed is a good one, and should be insisted upon in the case of thick plates, whether the plates are of steel or of iron. On boilers of large diameter having thick plates, it is sometimes necessary that they should be caulked both on the inside and outside; but for boilers of smaller diameter, having thin sheets from $\frac{1}{4}$ inch to $\frac{1}{2}$ inch in thickness, caulking on the outside alone is sufficient.

From the writer's experience he would not advise that the arrangement of the steam piping be so specified as to require many flange connections, owing to the liability of the gaskets blowing out, which, should it occur, would stop the plant entirely until a new gasket could be replaced; whereas if the piping is largely put together with screw joints, it is hardly possible to imagine a leak taking place in a joint which would not permit the plant to be run at least until it could be shut down without detriment to the interest of the party owning and operating the same.

When providing against radiation of heat, the cost of insulating material used and the method of applying the same would have a very large influence in completing such protection to the *entire* satisfaction of the Engineers and Architects. It is better for them to examine a form of covering, and arrange specification that insulation equal in merit to whatever they may approve shall be furnished. This would not exclude many good makes of insulating material which vary in price.

Alterations, extra work or material should be permitted to be ordered by the Owners, as well as the Engineers and Architects; as in the case of an emergency or unforeseen circumstance, the Engineers or Architects, or their representatives, might not be on the ground, and this might necessitate an expensive delay to the Builder.

The clause that the Engineers' and Architects' decision and interpretation of the drawings and specifications shall be final, conclusive and binding is a customary one in all specifications, yet a technical point with which they may be unfamiliar at the

time of drawing up the specifications might preclude the possibility of their being carried out, and yet they could insist under the agreement upon almost anything they choose. This by some is considered to be equal to saying that the Engineers and Architects are the only honest parties concerned.

As to risks, the clause reads, "the Contractor is to assume all risk and bear any loss occasioned by neglect or accident during the progress of the work," etc., this should be "his neglect," in order to relieve him from the blame attached to carelessness of parties with whom he has nothing whatever to do, and which would be manifestly unfair.

The drawings of the Engineers and Architects could be so made, with the dimensions thereon correct to survey, that the Engineers and Architects themselves should be responsible for any encroachments on neighbors. If it is customary for Owners to furnish a survey for Architects, there does not seem to be any reason why this same survey should not be furnished to the Builder; the Engineers and Architects marking base lines, as it is certainly their professional duty so to do, or have done by others.

The base of the measurement should in all cases be established by the Engineer and Architect; this would simplify matters, and in the event of mistakes, place the responsibility where it properly belongs.

The expense of the test, outside of the cost of the coal, should not be borne entirely by the Contractor, unless the plant does not come up to the requirements. In the case of the plant being accepted, at least one-half, if not all, of this expense should be paid by the Purchaser of the plant, for the same reason that he would pay his Architect for plans and specifications.

When penalties are stipulated, a "per-contra" clause should be inserted to provide for the Owners delays. This would give the Builder some compensation for his diligence in completing the plant in advance of the time specified; which is only a fair offset for a penalty exacted from him in case of delay in completion after the time agreed upon. Should the plant not be accepted, an allowance should be made for the use of the boilers during the time in which others were being obtained to take their place.

Without this allowance very few Builders would be willing to undertake a contract in accordance with these specifications.

The forfeiture of money to represent the cost of additional coal required to evaporate a sufficient amount of water in case the plant does not come up to requirements in this particular, is one to which few Builders would agree; and it is a question if this clause would not cut out the Owners from obtaining plants from some of the best boiler builders in this country.

The guarantee to keep boilers and accompaniments, except grate bars, in perfect running order for one year would hardly be signed by many Builders; inasmuch as some firemen can destroy a setting in less than six months, no matter how well or carefully it may have been built, and regardless of the material of which it may have been composed.

The prevention of discomfort and loss by radiation of heat should be guarded against if possible, but as to how far the former is allowable is a matter difficult to determine by any one interested; inasmuch as to the writer's knowledge no base of measurement has ever been established for personal discomfort.

The smoke stack should properly be separate from the boiler plant, inasmuch as unless its thickness and size is fixed, no two builders would likely agree upon the same proportions; and the man guaranteeing the plant and having the smallest stack, other things being the same, would of necessity get the contract, owing to his being lower in price.

When bids are asked for by Owners, and made in good faith by Builders, it certainly is not fair to reject all of these bids; at least one should be accepted. Otherwise the Owners, and the Engineers and Architects, are simply trifling with the time of the Builder, and putting him to an amount of expense for which they do not furnish him even the chance of any return.

Barring the foregoing, the specifications cover a great deal of ground which has hitherto been left open to a miscellaneous interpretation, and the specifications themselves are undoubtedly a step in the right direction, particularly so for the City of Philadelphia; as to the writer's knowledge there are no standard specifications worthy of the name, which will permit any and all builders of first-class boilers to compete in an open field without fear or favor.

In the writer's judgment, the Engineers and Architects should so frame their specifications that they cannot be accused of favoring any particular make or type of boiler, and at the same time ask for bids from *all* makers. If one particular type of boiler is preferred, there is no use of inviting builders generally to estimate, as it is wasting their time, for which at the start it is not contemplated to recompense them.

That which properly belongs to the building, such as stack and boiler foundations, should be excluded from the specifications; the boiler settings above the foundations, connections to smoke flues and small brick piers for holding feed pumps, are the only mason work which should properly be included in the requirements of the boiler building.

These remarks have been made at the request of Mr. Darrach, and the writer hopes they will be criticised to the fullest extent, that if possible a standard specification covering the ground may be ultimately obtained.

The question of a standard of measurement of efficiency is altogether outside of a general specification such as the writer understands Mr. Darrach's paper to be. This should be taken up and adopted separate and apart from a specification, inasmuch as it will then form a clause in the specification, being a detail, not general.

DISCUSSION.

By Arthur Marichal.

Read November 19th, 1887.

A general form of specifications, as proposed by Mr. Darrach, would be very desirable indeed, and especially for the engineer would be very convenient, since it would save him trouble or responsibility of any kind. If a gentleman comes to him and wants a boiler, he will take on his desk one of these blank forms of specifications, will fill it, and the boiler will make its appearance very soon. But, unfortunately, I think it is too convenient, and one main point has been overlooked—it is the question of economy.

When an engineer is writing specifications he must, undoubtedly, have in view to get the work done exactly like he wants, at a cost as low as possible.

Will the form of specification, proposed by Mr. Darrach, allow us to expect such a result? Certainly not. The engineer will be a judge, says Mr. Darrach; the party bidding will have to run the risk to have the boiler rejected if, in the opinion of said engineer, the quality of steam is not what it ought to be, or if the number of horse-power, as computed by said engineer, is not as required. The covering will not be accepted if the same engineer thinks it is not good, etc.

Conclusion:—The boiler maker has to run many risks, and, as he has not less brain than any other business man, he will increase his price accordingly. The specifications which you thought to be beneficial to you will be entirely at your disadvantage.

If an engineer wants a boiler, let him select in the market the type he thinks to be the best for the purpose it is intended for; let him make specifications in regard to dimensions, quality of material, workmanship, time allowed for construction, etc., avoiding probabilities, opinions of one or another or risks of any kind. Then the boiler-maker will know exactly what he has to do, without having to consider whether the engineer is competent or not, whether he is honest, whether he is a good judge or not, and the bid will be as low as possible, just the thing you were seeking.

We should not make a contractor afraid of bidding; on the contrary, we should engage him to bid. That is the best policy.

Even from a point of view of humanity it is unfair to make a man face a danger when we can possibly avoid it. In this case there is no reason whatever for making the specifications full of elements of uncertainty, and you go deliberately and fill them with risks of all kinds.

I know that sometimes we cannot avoid to leave some risk to a contractor, as, for instance, in the case of pier foundations for a bridge, not knowing the nature of the ground. I got such a case, and before advertising for bids I had soundings made and samples taken every 0.5 meter in depth, and kept at the disposition of any one who was going to bid, and that expense for sound-

ings was paid more than twenty times, by the fact that the contractor, knowing exactly the nature of the ground, was able to make very low prices without any extra charge for the risk to meet possibly a soil of a worse nature.

In concluding, I would say that it will always pay to make specifications simple and clear, with as few elastic clauses as possible.

DISCUSSION.

By G. R. Henderson.

Read November 19th, 1887.

I received a copy of Mr. Darrach's *Boiler Specifications* inviting discussion. I have read over the same carefully, and while they are, without doubt, very complete, and protect the purchaser amply, still I think they are most too exacting as far as the builder is concerned, and am afraid many builders, who make special types of boilers, would want to follow their own practice and use their own material.

In section headed "Alterations," it is specified that the engineers and architects are to be considered full and final authority for allowances in price due to alterations, as well as arbiters of any disagreement that may occur. This I do not consider as fair to the contractor, and doubt if many bidders would be willing to accept such indefinite terms, as very few contracts are carried out exactly in accordance with the original design, especially in work of this kind, where so many new phases are likely to be presented during the construction and erection of the work.

DISCUSSION.

By William Sellers.

Read————

The presentation of the Boiler Specifications by Mr. Darrach is a new departure in boiler construction, which I believe will have great consequences in the near future.

These specifications draw a sharp line between that which concerns the evaporation of water and the prime mover with which the evaporation has no connection, and they very properly place upon the constructor of the boiler the entire responsibility

for its performance with that of all its accessories. The effect of this must be to elevate the boiler-maker from the position he has heretofore held, of a mere workman, to that of an engineer, because each boiler plant will involve conditions different perhaps from any other, each of which must be carefully weighed to enable the constructor to devise a plan which will accomplish a favorable result, and this plan will be no haphazard affair, no experiment which the purchaser will pay for; if it fails, the designer himself must foot the bill, so that its determination will require the most careful calculation to guard against very serious loss. It will also require the most careful tests to determine the value of such changes as he may from time to time introduce.

This latter feature cannot fail to give more perfect knowledge of boiler performance than most boiler-makers now possess, and this in turn will develop better performance.

Nevertheless, there are some features in these specifications which are open to adverse criticism, although they are of minor importance, and first among these I would call attention to the quality of materials. The general tenor of the specifications is evidently intended to fix responsibility upon the boiler-maker, which in itself is not only proper, but commendable. They should not, however, contain provisions that involve practical impossibilities for him, but they start out with a requirement, that all steel plates must be made of open hearth steel. Will the author tell us how the boiler-maker is to know that he has open hearth steel unless he makes it himself? He may contract for open hearth steel, and he may have his inspector witness its manufacture; but this last would generally be a practical impossibility, that is to say, it would involve an expenditure which, if applied as it should be upon the boiler to be constructed, would probably lose him the contract; again, it must be stamped to show the brand and the name of the maker. Of what practical value can this be? Such markings to be permanent will, in all probability, injure the plate, while they can give no assurance as to the quality of the material; this is always determined by the physical test. Any further requirements will serve only to excuse the boiler-maker and add to the cost, without affording any additional security. Aside from this, I believe it to be outside the province of the engineer to define a process of manufacture

for the material he is to use. He may properly define the tests it must sustain to be accepted by him; anything beyond this will be found to retard instead of to facilitate improvement.

The physical tests prescribed in these specifications might be improved as follows: By erasing on page 3 "open hearth," also "stamped, showing brand of steel, name of makers." Page 5, altering first paragraph to read as follows: "Rivets must be driven either by hand or by a power riveter, the movement of which is determined by the resistance of the rivet to further compression."

As I would forbid stamping the plates, I would erase from page 5 "In constructing the boilers the stamps must be in such a position as to be easily seen on inspection."

With reference to dampers, I regard a multiplicity as objectionable, in that they afford opportunity for regulation that firemen ought not to have. A battery of boilers should have one regulating damper and facilities for cutting off any single boiler from the main flue. This may be a damper, but if so it ought not to be convenient for regulation. The requirement of three try-cocks with gauge glasses affords too many appliances for ascertaining the water level. There should always be two; and if you must have tri-cocks, let them be one of the two, but they require a skilled observer to use them properly, and their slop is a nuisance. Two good gauge glasses are, I think, far more reliable.

The penalties are perhaps the important features in this specification, and they merit the highest commendation, as it is through their intelligent use that improvement in boiler economy will be obtained. Not only this, but they afford a simple formula for determining the relative value of various types of boilers, as for example: A boiler is wanted to supply 100 indicated horse-power per hour, or, we will say, to evaporate 3,000 pounds of water per hour into dry steam, and three proposals have been made to furnish it. One guarantees to evaporate into dry steam 10 pounds of water per hour from and at 212 degrees, with one pound of combustible, another will evaporate 11 pounds, and the third 12 pounds. What is the relative value of the three?

By the term combustible is meant the heating material in the coal, which varies between 83 and 92 per cent. in good coals.

For the purpose of comparison, and assuming that in all other respects except economy the three boilers are equal, then you say that the value of the coal saved annually by the most economical boiler, over either competitor, should be capitalized at 6 per cent., so that the sum thus obtained would afford an income to pay for the additional coal required, and this sum, when added to the cost of the boiler in comparison, would afford a just basis of comparison upon which the user could safely determine which to purchase.

With the example selected, this would result as follows, upon a basis of 10 hours run per day, 310 working days per year, and $3.00 per ton as the value of the combustible in the coal:

1st boiler for combustible requires per annum,						$1,395 00
2d	"	"	"	"	"	1,268 10
3d	"	"	"	"	"	1,162 50

The third boiler saves $127 per annum over the second and $233 over the first, and capitalizing these sums at 6 per cent. gives $2,116.66 to be added to the cost of the second and $3,883.33 to that of the first, to make them equal to the third.

Any one at all familiar with the cost of boilers having a capacity of 100 horse-power will see at once that if they could obtain a boiler having an evaporative capacity and economy equal to that of the third, they could not afford to take either of the others as a gift, assuming that there is no choice between the competitive boilers except in the economical use of fuel.

I have only to add that when the discussion is closed it is to be hoped that Mr. Darrach will be able to formulate a specification for steam boilers that may become a standard for this character of work.

DISCUSSION.

By the Author.

I have only one objection to make to the discussion of Mr. Sellers, which is in reference to dampers. In regard to this clause I would state that the clauses in the specifications relating to dampers are alternate, the intention being to erase or cross out the dampers and regulators not needed. It is not the intention that all of the dampers and regulators should in every case be provided.

NOTES AND COMMUNICATIONS.

PHOSPHOR-BRONZE SPRINGS.

Regular Meeting, March 19th, 1887.—Mr. Wilfred Lewis presented the following:—About a year ago, in designing valves for hydraulic machinery, it became necessary to use springs in the water-ways, and to guard against corrosion it was suggested that they be made of phosphor-bronze.

No information, however, could be found for determining the proper size of wire and its probable extension or compression, and accordingly the writer undertook to make the following partial solution of the problem. A piece of wire .12 inches diameter and several feet long was obtained from our fellow-member, Mr. Lüders, for the special purpose mentioned, and coiled in the form of a spiral spring, $1\frac{1}{4}$ inches diameter from centre to centre, making 52 coils.

This spring was loaded gradually up to a tension of 30 lbs., but as the load was removed it became evident that a permanent set had taken place. According to formulæ recommended by D. K. Clark for helical steel springs, such a spring of steel should bear with safety a load of 20 lbs., while according to the practice of the P. R. R., it might be used for double this load, or 40 lbs. A weight of 21 lbs. was then suspended from the bronze spring so as to allow a small amount of vibration, and the length measured from day to day. In 30 hours the spring lengthened from $20\frac{5}{8}$ inches to $21\frac{1}{8}$ inches, and when suspended 200 hours its length was found to be $21\frac{1}{4}$ inches. It was concluded from this that 21 lbs. was too great for durability, and that probably 10 lbs. was as much as could be depended upon with safety.

For a given load it was found that the extension of the bronze spring would be just double the extension of a similar steel spring, that is, for the same extension the steel spring is twice as strong.

The above experiment is not very conclusive, but my practice now is to allow for phosphor-bronze springs the same extension or compression as for similar steel springs and let them carry one-half as much load.

CAMP AND FIELD LIFE ON THE UNION PACIFIC RAILWAY SURVEYS.

Business Meeting, June 18th, 1887.—Mr. C. H. Middleton presented the following:

Mr. Howard Murphy, *Secretary and Treasurer Engineers' Club of Philadelphia.*

Dear Sir:—After many days, your notice of the 14th ult., notifying me that I was appointed upon the Committee on Information, was forwarded to me at my camp here in the Rocky Mountains, and as I do not know who is chairman of the Committee, I will have to inflict you with this letter. I see by the notice that we are allowed considerable latitude in selecting a subject of interest, but wide as it is, I fear that I shall have to make a departure from the prescribed limits, and if it does not make a bad precedent, ask your indulgence. As I am many miles from my books, maps and drawings,

and the only interesting engineering works I have recently seen are those of Nature, it has occurred to me that, in lieu of something more scientific, an account of the way in which railroad surveys are made in this country might be of interest to many of the Club who have never had to "rough it."

The Union Pacific Railway is the pioneer, and to-day makes more locations, explorations and examinations into undeveloped parts of the country than any of the other Pacific companies, and its methods are fairly typical of the others.

The growth of business in newly-settled parts of the West is so rapid that it offers quite an inducement to the railroads, and a lively competition for the control of those districts among the railroads near them is sure to follow. This creates a demand for, and gives employment to, a large number of engineers.

As a rule, the engineers who have acquired all their experience in the West do not have the great variety of experience in construction which most of their Eastern brethren are favored with, but in "location" and reconnaissance the Western engineer is most favored. The Union Pacific Railroad Company has some old men who have spent all their time at this kind of work. Some of them have been engaged in similar work in Mexico and Peru. These older heads guide and direct those of less experience, with very good results. In this country, where so many hundreds of miles of railroads are built annually, it is of prime importance that the best and most economical location be had, and it is secured here with less time and expense than in the East.

The engineer who makes a specialty of railroad location and construction has a very favorable field in the West, while in the East it is becoming smaller and less profitable every year. In a prairie country, like Kansas and Nebraska, where it costs very little per mile to construct a railroad, and where the demand for them is always urgent, a number of locating parties are constantly in the field.

The party live in tents all the year round, and are furnished with two teams with which to move camp and haul supplies. Usually there are fourteen men in a party, including a cook and two teamsters. When the topography of the country is such as to require contours to be taken on the preliminary lines, two more men are furnished the topographer. Three tents, 14x16 feet, are furnished, as well as all other camp equipment. The members of the party merely provide their own blankets for bedding.

The "office tent" is furnished with drafting tables, stationary chest and all supplies necessary to make finished maps and profiles of the work. The engineer in charge of the party and transitman, levelman, topographer and rodman occupy this tent. A small wrought iron stove of the Franklin pattern, without any grate, gives ample heat, and if the party manages to carry their lamp without getting it broken, they have a good light.

The "mess tent," when presided over by a good cook, is always sure of unwavering popularity. The railroad company provides everything that is necessary to prepare the food, and they give the engineer in charge of the party full and entire discretion as to what to provide the cook with.

The parties all live well and even enjoy a great many delicacies. Of course there are times when the supplies do not come in on time, and sometimes the cook stove will not draw, and there are many little accidents that will now and then conspire to spoil a good dinner, but in general the mess tent is sure to contain comfort and good

cheer, no matter how gloomy the remaining part of the camp is. The remaining tent is used by the rank and file of the party as parlor, sitting-room, gymnasium and dormitory combined. This is always an interesting place and one that is not affected by anything external. The inmates of this tent are never troubled by the fluctuation of stocks or the war-clouds that threaten the destruction of a nation. They are of all ages, from all parts of the country, represent all temperaments and all conditions of servitude. Vital questions of religion, science, politics and business are discussed with astonishing freedom.

In the Winter, when the party is working where there is no shelter, a tent is provided for the horses. One team is usually kept with the party, taking them to and from camp, and, when practicable, moving the transitman from one point to the next. When the party is making ten miles a day, this assists very materially. All the stakes for the day's running, the dinner, and sometimes coats that are not needed on the work, are carried by this team. The other team is kept busy as soon as the party begins to get away from their base of supplies. At one time last Winter, when the roads were bad on account of snow-drifts, we had to send forty miles for supplies. Once every week we had to send map and profile and a report of the week's work to the Chief Engineer's office; the team was sent with that and for our mail; then there was fuel to haul, and sometimes we had to haul water. Between times, when there was no hauling to do, they were kept busy scouring the country in search of milk, eggs, poultry, etc.

At one time in the Spring, after the snow was gone and we no longer had any to melt, we had to haul all the water we used ten miles over hilly roads. It was in an unsettled country where there were no wells or springs, and the nearest stream, Platte River, was ten miles away.

I spent all of last Winter in camp, with nothing but a 12-ounce canvas tent for shelter at night and on days when we could not work. There were six other parties out in the Fall, but some were called in by the latter part of November, and only three others were in the field all Winter. A number of the engineers have been living in tents continuously for years.

In the mountains all surveys have to be discontinued between November and May, on account of the snow. During that time some of the parties are given work in the prairie country, and some are happy to be disbanded until work is resumed.

I was on location most of the time during the Winter and the line was ninety miles in length. The maximum curvature was three degrees and maximum grade one-half of one per cent. In two places there were five miles of continuous maximum grade. On curves the grade was equated five one-hundredths of a foot per degree of curvature, and all curves of less radius than 5,730 feet were spiralled or elasticised. This equation of grades seems trifling on the line above mentioned, but on other work where six degree curves are used it is important, as every good engineer knows. The spiralling of curves is done by running the curve on an offset and at each end of the curve, and on the adjacent tangent new offsets are made every 25 feet, fixing the line of the spiral.

The length of spiral on the curve and tangent is made equal, and at the point of curvature and tangent the spiral is midway between the original point and the offset from which the curve was run. The length of spiral and the offsets vary for different curves, and for the same curve where the topography of the country requires a light or heavy spiral.

It is the prevailing opinion among Eastern engineers that the work in the West is done in a very loose and slipshod manner, but in justice to all whom I have been associated with in this country, I can say that I have seen more care exercised to insure accurate field work than I ever did in my seven years' experience with the largest railroad company in the East. Although we sometimes run ten and twelve miles a day in favorable prairie country, it is never done at a sacrifice of accuracy. All distances are measured twice and double sights taken with the transit at every "set up;" that is, after taking a back sight and setting the point ahead, the instrument is turned half way around, a new back sight taken and another point set ahead; if it does not coincide with the point first set, one is established midway between them to run ahead from. This insures a straight line in case the cross-hairs are slightly out of adjustment. Any chance of error from parallax is diminished by reversing the direction of the instrument at each set up.

In all estimates the prismoidal formulæ is used, and it is not considered accurate enough to average end areas and multiply by the distance between them for the cubic contents.

Last Winter was a mild one and there were but few days when we could not work out doors. I hardly think that Philadelphians would see anything very mild about it, but in Nebraska they judge by a colder standard. From November to March we had snow, and the thermometer most of the time was below zero. On several mornings the thermometer in my tent was 20 degrees below, and outside of the tent it was too low for the thermometer to record. When the wind blew, as it generally does in Nebraska, we could not work when the temperature was 10 degrees below zero, but on calm, still days we could stand it on the coldest days. We had but two genuine blizzards. One of them lasted three days, and it was with difficulty that we kept our tents from being blown away. You may realize that we were very much concerned in the matter when I say that we were miles from any other shelter, and the same storm blew down a number of buildings. In the night we would sometimes have to go out and strengthen the ropes or put in more spikes to hold them. We had the mess tent blown down and badly torn one Sunday, just in time to spoil a good dinner, and kept us busy the balance of the day in repairing the wreck.

When we had good country to work in and not too much snow to wade through, we ran from two to four miles of location per day. That would necessitate our moving camp about once a week. In Winter, when the snow is deep, moving camp is the most unpleasant thing to do. If a long move has to be made and the roads are bad, the loads have to be made up and started early, in order that they may reach the next camping place and have tents pitched by night.

On moving days we usually had to turn out at half-past four, and pack up and load everything on the two wagons, except the mess tent, before breakfast. The party would then go out to work, and the cook and teamsters afterward finished loading and would try to reach the new camping place, and clear off some snow and get up one or more tents by the time the party came in from work in the evening. In the Summer, when the party is running from five to ten miles per day, the moving day comes oftener.

I know of one party, on preliminary work in the Platte River Valley, that averaged 10 miles of line per day, all one Summer. When it did not take too much time to get connections with the section lines, they moved camp every day, and sometimes

only every other day. Under such conditions a man would be apt to question whether life were worth living.

When we are in a farming district where corn is cheap and coal would have to be hauled a long distance, it is much cheaper to use corn (on the cob) for fuel. Most of the time last Winter we used corn for that reason. It cost from sixteen to twenty-two cents per bushel, and coal was worth just twice as much. It burns readily and makes a hot fire. We seldom had any trouble to heat our tents even in the coldest weather. A tent will doubtless seem like very poor shelter, but after laying out with nothing but blankets for a covering, as we had to do many a night, we have learned to appreciate it.

One of the trying things peculiar to the West which we have to do, is to get connection with all the section lines and corners near our surveys. These corners have been established by all kinds of methods except the proper one, and it is rarely that we find them as they should be. They were originally put in by contract, and if the contracts were not awarded to the lowest bidder they surely must have been given to the most incompetent ones. It was a poor policy which led to this false economy on the part of the Government, and it has cost the people interested in it more than would have been required to do it properly at first. The trouble which is experienced by the railroad companies arises from the fact that the sections are recorded at the Surveyor-General's office as being established accurately, just as the contractors were paid for doing it. Now, in order to hold a location and for Government information, our maps, reduced to a scale of 2,000 feet per inch, showing all townships and sections, etc., have to be filed with the Government at Washington. These connections are shown just as they occurred on the ground and in a line of 100 miles long. Some places are going to be badly displaced when they plat the line on a section map which is not as it is on the ground.

This sometimes makes wonderful changes in the geography of the country. I know of one place that is not within five miles of where it is recorded to be in the Surveyor-General's office. We found a river recorded as being one mile from where it actually flowed, and it had not changed its channel. A long line seldom passes through all the sections, which it would have to in making it fit a Government map, and if it goes through them at all it is not as it really does on the ground. The result of it all is, that instead of a line being where it is recorded to be, it is a mile or more away.

The Union Pacific Railway Company have three parties in the Rocky Mountains besides mine, and two parties up in the range on reconnaissance. They also have two parties in the Bitter Root Mountains in Idaho.

I am on the western slope of the "Continental Divide" in Southern Wyoming, and we are running southward to cross the "Divide" near Hantz Peak, at or near the northern line of Colorado.

The gold and silver mines in Northern and Western Colorado, and the coal which is yet undeveloped, are the inducements which led the Company to make the surveys. The Company now owns and operates a system of narrow gauge railroads in Colorado, which were built in times of mining exitement and before the value of the different fields was determined or even questioned.

All surveys being conducted at present are for broad gauge, and the territory to be developed is undergoing the examination of the Company's experts.

The snow on the mountains this far north lasts much longer than it does farther south in Colorado. The parties working down there have not had as much trouble with the snow and water as we have who are in Wyoming. The melting snow floods the streams, so that at times it is impossible to ford them or cross in any other way. The water is cold as ice and runs like the tail race of purgatory. Not many of the streams have bridges, and it is often impossible to get to those that exist. Sometimes a party are cut off from their supplies, just when they need them, by a stream suddenly rising a couple of feet and preventing the return of the teams. Boats are not often to be had, and cannot always be managed when procured. The snow usually thaws during four hours in the middle of the day and then freezes during the night. An unusually warm day or a rain (which is raw) makes a flood, and it is hard to tell when it is coming.

Last month a member of one of the parties, who are north of us, tried to cross the Platte River in a dug-out at a rope ferry. The current was so swift that it swamped the boat and drowned the man, although he held on to the cable which was securely suspended over the stream.

The stream along which I am working is so full of rocks that a boat would be crushed as soon as it was launched. It is too deep and wide to fell trees so as to make a foot-bridge, and we cannot cross it at all.

We are running a preliminary line, and no matter how sharp a bend the creek takes, or how inviting the land on the opposite bank, we remain on one side all the way. A location in such a place would have to be made late in the Summer or early in the Fall.

Most of the snow, below the snow line, is melted by the middle of July, and the streams then become very small.

The men in the mountains on reconnaissance obtain their elevations with the adjusted barometers, which show the equivalent height of a column of mercury to the one-twentieth of an inch, and the corresponding elevation in feet up to 12,000 feet above sea level. We are all furnished with exactly the same instruments, and twice each day note the variation between the correct elevation of camp and that shown by the barometer. When these reports are compiled, and it is found which were local and which general variations, and how the relative elevations affect the variation, it will be of great assistance in determining the allowance to make for the results of the reconnaissance. On May 15th my barometer read 320 feet lower than the correct elevation and on the 21st 280 feet above, showing a variation corresponding to 600 feet. This variation was at an elevation of 7,020 feet, and is the greatest that has yet been reported by any of the parties. The greatest variation on one day in my camp is 240 feet, and the least is 25 feet.

When we came into this country on the first of May, we left the railway at Laramie, and just as the church bells were ringing we started out over the "Laramie Plains" with three teams and fifteen men. It is always customary in this country for the party to walk when moving camp, and as we were not novices we followed the teams, and kept following them for seven days and tramped just 135 miles. It took a week to get in to where we began work on the survey.

On account of the more direct routes being impassable by snow and the streams too high to ford, we had to go southwestward into Colorado and then northwestward back into Wyoming. On the first day we crossed the plains and reached the foot-hills of

Medicine Bow. It was good country for tramping and we made 30 miles. After that we had mountain roads and hard traveling all the way. Two of the teams gave out in the first three days and had to be replaced with fresh ones. In many places where there was timber the snow along the roads was six feet deep. One team was stuck in a snow bank an hour and had to be shoveled out. There were places where the roads were so steep that all the horses would have to be put on to each load in succession until all were hauled up.

In the valleys there were some bad marshes to go through, and many a time were the wagons stuck fast in mud, axle deep. Sometimes the horses would sink in to the knees, and then we had to take the load off and get the wagon out before we could put horses to it. In fording some of the streams the loads had to be lightened and arranged so as to keep the bedding and supplies dry; the horses had to swim.

We made but one attempt to cross the country by a short route. After climbing Independence Mountain, where we were 10,200 feet above sea-level, we found the road blocked by snow, so that we had to turn back and go down 1,200 feet to the road that went around the long way.

While on the move we did not pitch the whole camp every night, but merely the mess tent and what was necessary for the cook. After supper we would pick out a place where the rocks were fewest and roll our beds out. Someone would have a big camp-fire started by that time, and the musicians of the party would enliven our spirits with the violin and banjo, and sometimes the flute. One by one we would leave the fire and roll up in our blankets, and the trials of the day were soon forgotten. A couple of inches of snow fell one night while on the move, but we had an extra tent up and were ready for it.

Not long after getting in here the "mountain fever" began its work on the party, and at one time five of the men were down with it. Three of them left and two others had to be sent to the Union Pacific hospitals. Two more are now sick and not able to be out.

The Company has three hospitals, at Omaha, Denver and Ogden, which are supported by an assessment of 25 cents per month on all employees. Treatment at the hospital, or by any of the Company's physicians along their lines, is furnished gratis to employees. When a man is sent to hospital his pay is continued for one week, but he is kept there under treatment without any charges whatever until cured. In cases where an employee cannot get treatment and medicine from a Company physician, or get to a hospital, the cost of treatment is paid for from the Hospital Fund.

We are now encamped in a cañon where there is just width of bottom land sufficient for a tent. In front of the tents the Encampment Creek rushes over the rocks, making as much noise and fuss as the Atlantic Ocean. Just back of us the granite wall runs up hundreds of feet nearly vertical, and then slopes gradually to a height of 1,000 feet above the creek. There is no road near us, and we have to move our camp with pack mules, and get our supplies in the same way.

I had to send down into Colorado, 100 miles, to get as many mules as we need to pack our camp with. We have 16 mules, burros, mustangs and bronchos, and two experienced men drive and care for all of them. Each animal is provided with a pack saddle, and when properly loaded can carry 300 pounds over a very steep trail. Our cook stove and some other things have to be taken apart to load on the saddles. The tent-poles and mess-chest and table have to be abandoned

and temporary ones made at each new camping place. Moving camp with a train of pack mules involves the party in a number of risks, inconveniences, denials, and sometimes considerable labor. With no road or trail to follow, and with endless rocks, underbrush and trees to avoid, the mule and its load are liable to an occasional accident. All these things, however, are taken as a matter incidental to the work, and are not of as much annoyance as they may seem to engineers who are not familiar with them.

There is much to look after in addition to the engineering work, and it is entirely new to an Eastern man, but he gradually becomes familiar with the new duties and finds quite a variety of demands on his resources.

I hope that at least a portion of what I have written will prove interesting to some members of the Club, and if not, I ask them to be charitable in passing criticism as it is offered only because the writer is prompted to do so by a sense of duty.

C. H. Middleton,

Assistant Engineer Union Pacific Railway.

CALORIMETRIC INVESTIGATION OF THE PERFORMANCE OF A COMPOUND ENGINE.

Regular Meeting, November 19th, 1887.—Mr. W. H. Nauman presented the following:

The purpose of this paper is to give an analysis of the results obtained in a series of interesting trials under varying conditions with a compound engine of 150 indicated horse-power. This engine, which furnished a portion of the motive power of a large worsted mill at Augsburg, Bavaria, was of superior workmanship and had been only six months in use. The primary object of the trials was to determine whether the efficiency of the engine came up to the requirements of the contract, but the trials were extended for the purpose of determining the influence of the steam jackets on the large cylinder and receiver, and of the size of the receiver on the economic efficiency of the engine. The experiments were conducted by Professor M. Schroter of the Technological High School of Munich, Bavaria, who has published accounts of them, and elaborate investigations of the results obtained, in Vol. 237 of "Dingler's Polytechnisches Journal," and in Nos. 1 and 2 of Vol. 1881 of "Der Civilingenieur." The present paper gives a digest of these several accounts as far as they are of importance for a calorimetric investigation of the efficiency of the engine in these trials. The computations and investigations in this paper have been made, by the translator, Passed Assistant Engineer C. R. Roelkea, U. S. Navy, to a great extent independently of those presented in the original accounts of these trials.

The engine is of the compound type, consisting of two horizontal cylinders with an intermediate receiver. The axes of the cylinders lie in the same horizontal plane, parallel to each other and 10.54 feet apart. The cranks, to which the pistons are coupled, are placed at an angle of 90 degrees. The horizontal shaft carries a large broad-faced fly-wheel, from which the power is transmitted by means of rope-gearing to the machinery of the mill. Each cylinder is surrounded by an annular steam jacket, and well clothed with mineral wool and lagged with wood. The jacket of the small cylinder communicates directly with the main steam pipe, and the steam enters

the main valve of this cylinder from the jacket space. The jacket of the large cylinder is connected with the main steam pipe by means of a branch pipe. The piston rod of the large cylinder extends through the back head. Both cylinders are provided with adjustable cut-off valves. The receiver consists of a pipe having an internal diameter of about 9 inches and a length of 8.53 feet, which extends underneath the floor of the engine room between the two cylinders, and of a second pipe communicating with the former one and placed at a right angle to it, below, and parallel to the axis of the small cylinder. This second receiver pipe has an internal diameter of 13.78 inches and a length of 43.3 inches; it is not steam-jacketed, but is well protected by a clothing of mineral wool and wooden lagging. The first mentioned receiver pipe is surrounded by an annular steam jacket, connected by a branch pipe with the main steam pipe; it is also protected by a clothing of mineral wool and wooden lagging. The steam is exhausted from the large cylinder into a jet condenser.

Steam is supplied by two horizontal boilers.

During one period of these trials (marked *b* in the Tables) only one boiler was used; but it is assumed that the economic performance of the engine was not affected thereby, since previous experiments proved that one boiler could easily supply the steam required for the engine. The diameter of the steam pipe is 4.72 inches, and its length between boilers and engine about 72 feet.

The following are some of the principal dimensions of the engines:

	Small cylinder.	Large cylinder.
Diameter of cylinder	14.57″	24.08″
Stroke of piston	30.40″	37.44″
Diameter of piston rod	2.93″	2.93″
Volume swept by piston per stroke (mean)	3.534 cu. ft.	9.7224 cu. ft.
" in clearance and steam posts . .	0.1515 "	0.3012 "
" of jacketed receiver	3.7047 "	
" " unjacketed "	7.8435 "	
" " both receivers	11.5482 "	

The volumes of clearances and steam passages were determined by filling the cylinders with water. The capacities of the receivers were calculated from the drawings. The other dimensions were found by direct measurement of the engine.

During all the several trials the steam pressure and the speed of the engine were maintained as nearly as possible uniform, and the valves were set to cut off the steam at very nearly the same point. The only changes made in the conditions of the experiment were as follows, viz.:

(*a*) Steam admitted to jackets of small and large cylinder and receiver.

(*b*) The above experiment repeated.

(*c*) Steam admitted to jackets of small cylinder and receiver only.

(*d*) Steam admitted to jacket of small cylinder only.

(*e*) Volume of receiver reduced by shutting off unjacketed portion; steam admitted to jackets of small cylinder and receiver.

(*f*) Volume of receiver reduced by shutting off unjacketed portion; steam admitted to jackets of small and large cylinders and receiver.

The above designation of these several experiments by letters will be retained throughout this paper.

The boilers were fired with great care during all the experiments, and the variations in steam pressure were so small as to be without appreciable influence on the working of the engine. The throttle was carried wide open in all the experiments.

The power for driving the machinery was partly derived from two turbine wheels. Of these, one was disconnected during the trials and the other was used as an auxiliary motor, which was made to supply more or less power, according to circumstances, so as to keep the speed of the steam engine as nearly as possible uniform. In the small cylinder, the point where the steam cut-off valve closed remained practically unchanged during the whole time of these trials. The cut-off valve of the large cylinder was always regulated during the first quarter of an hour, after the commencement of each trial, in such a manner that the terminal pressure on the small cylinder was the same as the pressure in the receiver; after such adjustment the cut-off remained unchanged during each trial.

During these trials the engine remained in operation from 6 A.M to meridian, and from 1 P.M. to 7 P.M. Each trial occupied either a whole or a half day. At 5.45 A.M. and 12.50 P.M., on each day, the height of the water in the boilers was noted and the boiler stop-valves were opened. The water which had collected in the steam pipe and engine before the latter was started was drained off and weighed separately.

After opening the engine stop-valves a complete set of indicator diagrams was taken every quarter of an hour. An ingenious arrangement of the indicators made the motions of their pistons exactly coincident with the motions of the engine pistons and made the diagrams of precisely the same length. The indicators were carefully tested before and after the experiment. The mean card calculated from the whole number of cards gave a fair curve without correcting the mean results obtained. The thermometers and steam gauges were likewise carefully tested.

The water condensed in the jackets, in the receiver and in the steam pipe during the trials was measured, each quantity separately as it was drained off.

The feed water was weighed in a tank on a platform scale, being delivered into the tank by an injector, which heated the water up to 95 degrees Fahrenheit. From this tank the water flowed through a valve in the bottom into a reservoir, whence it was fed into the boilers by a steam pump, supplied with steam by a separate boiler. The exhaust steam of this pump heated the water to about 117 degrees Fahrenheit.

The water discharged by the air pump was measured in an indirect manner, by observing the height of the water-level in a tank into which the water was discharged above an overflow opening, for which a co-efficient of discharge had been determined experimentally. From the data thus obtained the weight of water discharged was calculated. The results proved, however, not sufficiently accurate for use in a calorimetric investigation of the performance of the engine.

It is assumed in the accounts of these trials that the steam contained 3 per cent. of moisture. It is not stated, however, on what grounds this assumption is based. In the following investigation this condition of the steam is assumed to be correct: Lines 3, 5 and 6 of Table I show that for the different trials the variations in the boiler pressure, the degree of expansion and the speed of the engine were so very slight that they could not exercise any appreciable influence on the economic performances; and in investigating the action of the steam in the cylinders, these elements may be considered as constants in these trials. Line 8 gives the weights of

steam condensed in the warming up of the pipes and the engine previous to the commencement of the trials, and line 9 gives the weights of steam condensed in the main steam pipe during the trials. The sum of these two quantities subtracted from the total weight of water fed into the boilers, line 7, leaves as a remainder the weight of steam which actually entered the engine, line 10; with the latter quantity we have to deal in an investigation of the economic performance of this engine under the different conditions of these trials.

Considering that in the six-hours' trial (*e*) the weight of steam condensed in warming up the engine was more than two per cent. of the total weight of feed water consumed, we readily see to what erroneous conclusions the neglect to eliminate this quantity may lead, especially in trials of short duration. This remark applies also to the weight of steam condensed in the steam pipe, which varied between 3.5 and 4 per cent. in these trials. We must remember also that by neglecting to drain the steam pipe thoroughly we cause not only an apparent, but an actual diminution of the economic efficiency of the engine, for it is a well-established principle (of which the present trials will furnish instructive illustrations), that the presence of moisture with the steam in the cylinders always lowers the dynamic efficiency of the latter.

Line 11 contains the weights of steam condensed in the jackets during the trials, and line 24 gives the same weights expressed in per cent. of the total weight of steam entering the engine. The weight of steam condensed in the jackets of the small and large cylinders and of the receiver, when all or several of them were in use, are not given separately, but the experiments enable us to determine these quantities with a sufficient degree of exactness, as it will be seen from the figures in line 24, that when the same jackets were in use the weight of steam condensed in the jackets, relatively to the total weight consumed in the engine, varied but slightly. When the jacket of the small cylinder alone was in use (experiment *d*) the weight of water drained from the jacket was 2.65 per cent. of the total weight of steam entering the engine, and we may assume that this same proportion of steam was condensed in the jacket of the small cylinder in the other experiments. When the jackets of the small cylinder and receiver were in use (experiments *c* and *e*), the mean weight of water drained from them was $[4.62 + 4.69] \div 2 = 4.655$ per cent. of the total weight of steam entering the engine. From this we find $4.655 - 2.65 = 2.005$ per cent. as the mean weight of steam condensed in the receiver jacket, and we may assume that the same proportion of steam was condensed in the receiver jacket during the experiments *a*, *b* and *f*. When all three jackets were in use the mean weight of water drained from them in these experiments was $[10.52 + 11.5 + 10.69] \div 3 = 10.9$ per cent. of the total weight of steam consumed, and consequently on the foregoing assumptions the mean weight of water condensed in the jacket of the large cylinder was $10.9 - 4.655 = 6.245$ per cent. of the total steam used in the engine.

Line 3 gives the pounds of water drained from the receiver, and line 25 gives the same quantities expressed in per centum of the total weight of steam entering the small cylinder.

When all three jackets were in use (experiments *a*, *b* and *f*), the mean weight of water drawn from the receiver was $[2.52 + 2.32 + 2.43] \div 3 = 2.423$ per cent. of the steam entering the small cylinder. When the jacket on the large cylinder was

not in use (experiments *c* and *e*), the mean weight of water drawn from the receiver was [2.83 + 2.88] ÷ 2 = 2.855 per cent. of the weight of steam entering the small cylinder. The increased condensation in the receiver, due to the chilling effects of the sides of the large cylinder, is a curious phenomenon. The largely increased condensation in the receiver in experiment *d*, strikingly illustrates the efficiency of the steam jacket on the receiver.

Comparing the quantities in column *f*, line 25, with the mean of those of columns *a* and *b*, and the quantity in column *e* with that of column *c*, we are led to conclude that the loss of heat by radiation from the unjacketed part of the receiver was inappreciable, and that the loss by external radiation and conduction from the jackets was likewise very small. As the initial steam pressure, the degree of expansion and the speed of the engine were very nearly uniform in all the different trials, the number of indicated horse-power developed in each case represents very nearly the efficiency with the respective modes of working. We readily see that the diminution of the volume of the receiver did not produce any effect on the efficiency of the engine. We shall, therefore, find the mean efficiency of the engine when all three jackets were in use from experiments *a*, *b* and *f*. The mean indicated horse-power in this case was [129.38 + 131.07 + 130.83] ÷ 3 = 130.43; and when the jacket of the large cylinder was not used, the mean indicated horse-power, according to experiments *c* and *e*, was [121.84 + 119.93] ÷ 2 = 120.885. Consequently the omission of the jacket on the large cylinder diminished the power developed [130.43 — 120.885] ÷ 130.43, and multiplied by 100 = 7.9 per cent. The omission of the steam jacket, on both large cylinder and receiver, diminished the power developed [130.43 — 114.74] ÷ 130.43, and multiplied by 100 = 12 per cent.

The economic efficiency of the engine measured by the quantity of feed water, consumed per hour per indicated horse-power with all three jackets in use, was [14.920 + 14.394 + 14.527] ÷ 3 = 14.614 lbs.; without jacket on large cylinder [15.219 + 15.317] ÷ 2 = 15.268 lbs., or an increase of 4.5 per cent.; without jackets on large cylinder and receiver = 15.914 lbs., or an increase of 9 per cent., and a corresponding decrease of efficiency. The net horse-power are the indicated horse-power, less the power required to run the engine proper unloaded, at the same speed as found by experiment. It was found that an indicated pressure of 1.2 lbs. per square inch was required to run the engine at a speed of 71 revolutions per minute, when disconnected from shafting and fly-wheel.

TABLE I.

Containing the data of a series of Experiments with a Compound Engine, made at Augsburg, Bavaria.

		a	*b*	*c*	*d*	*e*	*f*
1	Date of experiment	Apl. 6, '80	Apl. 7, '80	Apl. 8, '80	Apl. 5, '80	Apl. 9, '80	Apl. 9,'80
2	Duration of experiment in hours and minutes	12.03	12.03	12.02½	5.58½	6.04	5.59½
3	Steam pressures in boilers, above zero	97.14	98.00	98.85	96.86	98.71	98.85
4	Atmospheric pressure, above zero	13.80	13.80	13.80	13.80	13.80	13.80
5	Number of times steam was expanded in both cylinders . . .	13.81	14.12	13.57	13.77	13.48	13.42
6	Mean number of revolutions per minute	71.195	71.39	71.34	71.13	71.36	71.33
7	Pounds of feed water consumed .	24,563	23,880	23,423	11,401	11,787	12,018
8	Pounds of water drawn from steam pipe and jackets before starting engine	348	260	298	68	239	229
9	Pounds of water drained from steam pipe during trial	956	886	795	423	404	401
10	Pounds of steam entering engine	23,259	22,734	22,330	10,910	11,144	11,388
11	Pounds of water drained from jackets during trial	2,448	2,613	1,032	289	523	1,218
12	Pounds of steam entering small cylinder	20,811	20,121	21,298	10,621	10,621	10,170
13	Pounds of water drained from receiver during trial . .	525	467	603	453	306	247
14	Pounds of steam entering large cylinder	20,286	19,654	20,695	10,168	10,315	9,923
15	Per cent. of moisture in boiler steam	3	3	3	3	3	3
16	Temp. hot well in degrees Fahr.	70,61	70.61	71.56	71.60	71.78	72.14
17	Temperature of feed water, Fahr.	113.54	115.52	114.44	116.78	116.06	115.52
18	Total H. P. of engine	146.91	147.14	141.95	135.56	138.02	147.57
19	Indicated H. P. of engine	129.38	131.07	121.84	114.74	119.93	130.83
20	Net H. P. of engine	119.54	121.20	111.98	104.91	110.07	120.97
21	Steam consumed per hour, per total H. P., lbs.	13.704	12.822	13.064	13.470	13.309	12.880
22	Steam consumed per hour, per I.H.P., lbs	14.920	14.394	15.219	15.914	15.317	14.527
23	Steam consumed per hour, per net H. P., lbs.	16.145	15.562	16.556	17.407	16.684	15.708
24	Water drained from jackets in per cent. of weight of steam entering engine	10.52	11.50	4.62	2.65	4.69	10.69
25	Water drained from receiver in per cent. of total weight of steam entering small cylinder .	2.52	2.32	2.83	4.27	2.88	2.43

TABLE II.

Showing the action of the steam and the distribution of power in the cylinders, as calculated from the indicator diagrams and other data of the experiments contained in Table I.

	Small Cylinder.	*a*	*b*	*c*	*d*	*e*	*f*
1	Pressure at beginning of stroke . . .	94.58	95.58	96.43	95.01	96.72	96.01
2	" " " " expansion .	77.80	80.08	80.22	78.94	77 80	77.09
3	" " end of stroke	20.05	20.05	21.05	20.84	20.62	20.48
4	" " " " compression . . .	59.31	73.96	74.53	67.56	74.96	75 53
5	Total work done in foot pounds, per stroke, during steam admission . . .	10,948	10,872	11,401	11,183	11,502	11,527
6	Total work done in foot pounds, per stroke, during expansion	14,151	14,201	14,622	14,097	14,209	13,947
7	Indicated work done in foot pounds, per stroke, during expansion						
8	Indicated work done for one complete stroke (foot pounds)	13,138	13,058	13,754	13,572	13,015	12,706
	Large Cylinder.						
9	Pressure at beginning of stroke	23.67	24.13	22 60	20.93	24.03	25.79
9½	" " " " expansion .	15.94	16.29	16.26	15.80	16 17	16.43
10	" " end of expansion	6.83	6.83	5.97	5.69	5.83	6.40
11	" " " " compression	23.18	24.18	20.77	18.77	21.33	25.74
12	Mean back pressure in pounds	2.90	2.65	3.30	3.44	2.99	2.76
13	Total work done, per stroke, during steam admission (foot pounds) . .	13,141	13,141	10,832	9,906	10,932	13,381
14	Total work during expansion	7,766	7,806	8,243	7,965	7,965	8,045
15	Work done, per stroke, against back pressure	4,062	3,713	4,620	4,829	4,182	3,863
16	Indicated work done during one complete stroke	16,845	17,234	14,455	13,042	14,715	17,563
17	Steam consumed in engine, per stroke, per cent.	100	100	100	100	100	100
18	Moisture contained in steam, per cent.	3	3	3	3	3	3
19	Steam condensed in jackets, per cent.	10.52	11.52	4.62	2.65	4 69	10.69
20	Steam entering small cylinder, per cent.	89.48	88.48	95.38	97.35	95.31	89.31
21	Dry steam in clearance at beginning of stroke, per cent.	9.43	11.89	12.19	11.24	12.36	12.03
22	Dry steam admitted to small cylinder and present in clearance, per cent. .	97.03	97.72	104.71	105.67	104.81	98.66
23	Dry steam at beginning of expansion, per cent.	79.48	81.97	86.82	84.92	85.79	82.45
24	Dry steam at end of expansion, per cent.	82.61	84.75	90.19	88.42	89.34	85.74
25	Water drawn from receivers, per cent.	2.26	2.06	2.65	4.15	2.75	2.21
26	Steam entering large cylinder, per cent.	87.22	86.42	92.73	93 20	92.56	87.10
27	Dry steam in clearance at beginning of stroke, per cent.	7.74	8.26	7.27	6.70	7.53	8.69
28	Sum of 26 and 27	94.96	94.68	100.00	99.90	100.09	95.79
29	Dry steam at beginning of expansion .						
30	" " " end of expansion, per ct.	81.56	83.67	75.06	72.60	74.09	78.09

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BOOK NOTICE.

THE ECONOMIC THEORY OF THE LOCATION OF RAILWAYS. By Arthur Mellen Wellington. New York, 1887.

Ten years ago the first edition of this work was issued and instantly achieved success. Though the style was often obscure, it was the only book that treated on the subject. Most of the location of new roads was in the hands of men who had gained their knowledge entirely by experience in the field, who had been connected with engineering parties from their youth up, beginning as chainmen or rodmen, and whose energies were expended in improving trifling details of alignment, without a proper conception of the true effects for producing a maximum return on the investment of capital, of distance and curves, ruling gradients and traffic centres. The present edition of the book is a very great advance over the previous one. A great part of the intervening time must have been employed by the author in accumulating facts, and the large amount of research displayed in the numerous tables indicates not merely enormous industry, but likewise peculiar advantages for collecting detailed information. The result is a work which all locating civil engineers must have in a most accessible place in their libraries. It is true that even yet we may be often irritated by the style of the author, but all will be willing to overlook this in consideration of the service he has rendered them. Even though his dogmatism will often arouse the spirit of contradiction, yet as the author, on a little reflection, generally seems to be right, one can overlook the annoyance. The society is never pleasant, however, of a very positive man, who tells another squarely that he is wrong. This was probably the fault of Dr. Fell, so well known in English nurseries, to whom the repugnance could not be explained.

Mr. Wellington too often condemns the work of others when he takes his information at second hand, and may be sometimes incorrect in fact, and at others may not know all the motives that actuated those whom he criticises, which motives would perhaps have similarly governed Mr. Wellington himself. Descriptions

of work are seldom given in sufficient detail in popular notices, or even in professional papers, to enable one to use them for a different purpose to what the writer intended.

As far as most railroads are concerned, it may be doubted whether Mr. Wellington has not magnified the evils of a bad location in a financial point of view. Certainly one would think that in a country where the capital charge is only one-third that of the railroads of England, and rates are not very different on passenger traffic, and about one-half as much on freight, that they ought to pay much more handsomely, even though the interest rate is less in England; whereas, the contrary is the fact. The reason is, however, rather in unrestricted competition than in bad location. The layman would say the remedy for a railway not paying would be to raise the rates. Railroad men know that this cannot be done arbitrarily. It is probable that even if a better location caused more economy in working or first cost, that rates would be reduced so as to neutralize the advantage to the stockholders. The true remedy seems to be, to prevent the paralleling of existing roads, which is a legislative rather than an engineering one. Until the legislators become capitalists, there seems no prospect of railroads experiencing any such relief.

One striking peculiarity of American railroads is, that so many of them were built without any expectation of the shareholders receiving a profit, the latter going to the bondholders, who receive a bond for more than they invest in money, or else to the owners of property which will be greatly benefited by the construction. Business must be stimulated at the expense of rates, and only the public at large is interested in the reduction of cost which a better location allows, and the way in which they are regarded by the great capitalists is shown by a celebrated remark of one of them—"D—— the public." The saving to the stockholders by a more judicious location is therefore of small interest to the original projectors who build the road. C.

Phototype. F. Gutekunst. Philadelphia.

Very sincerely yours
Thos M. Cleemann.

PRESIDENT DURING THE TENTH YEAR OF THE CLUB, A.D. 1887.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

NOTE.—The Club, as a body, is not responsible for the facts and opinions advanced in its publications.

Vol. VI.] FEBRUARY, 1888. [No. 4.

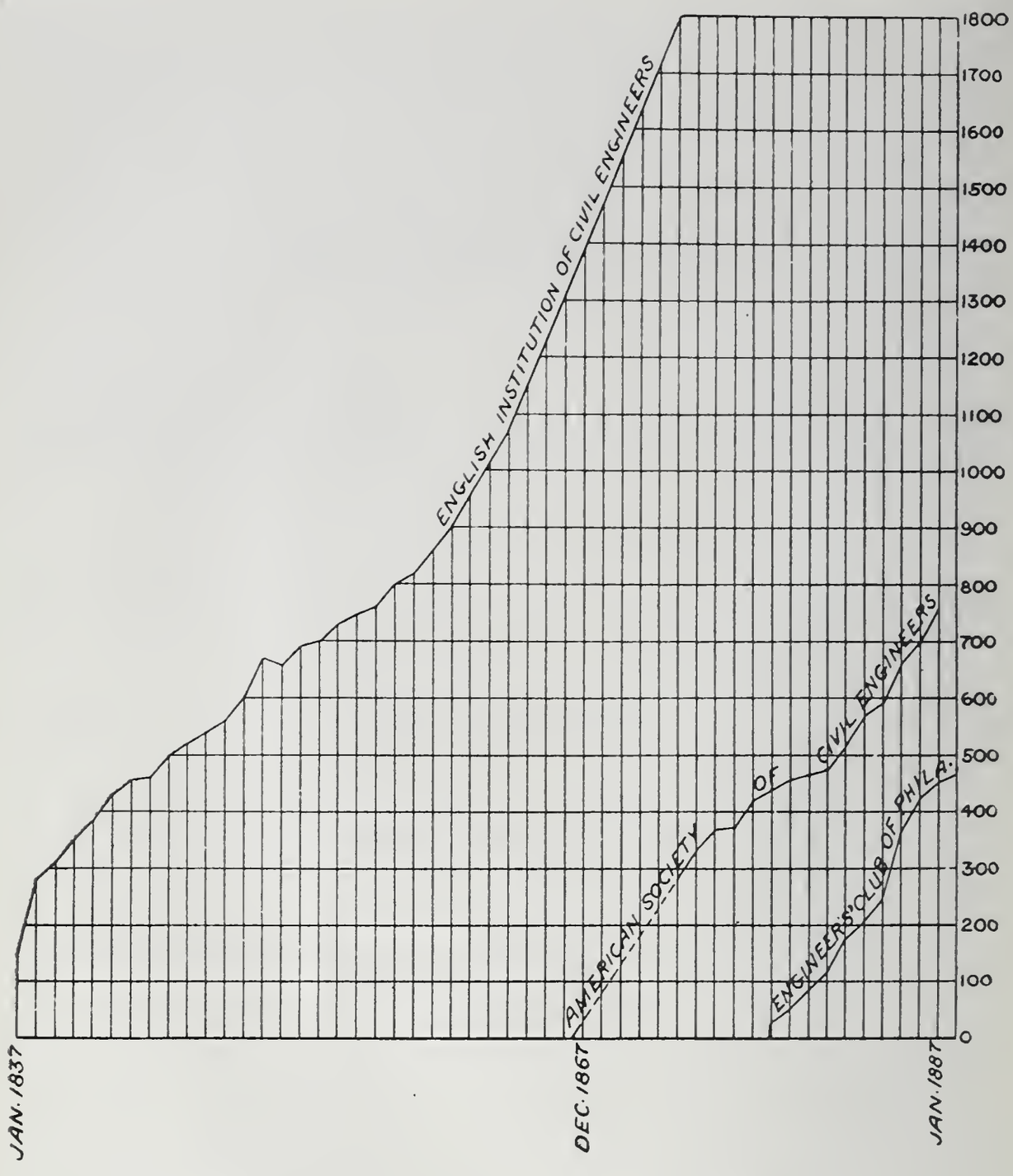
ANNUAL ADDRESS

OF

THOMAS M. CLEEMANN, Retiring President.

Delivered January 14th, 1888.

GENTLEMEN:—It is very gratifying to me, in delivering over to my worthy successor the high office to which you called me, that the Club has continued to prosper during my term, and that its membership has increased 2.4 per cent. We have just celebrated our tenth anniversary, and it seems to me that it will be interesting to compare our growth with that of other similar associations that have preceded us, and whose success should be a strong incentive to us to emulate them, and show how a local society in the chief manufacturing city compares with those professedly national, with their much larger field from which to draw. To illustrate this I have prepared a diagram, showing the growths of the English Institution of Civil Engineers, the American Society of Civil Engineers and our own Club:



A hypothetical extension of one of these curves seems to place our Club in the position of our leading American Society, as far as numbers are concerned, within another decade. Whether the future shall prove the accuracy of this forecast or not, depends largely on you, gentlemen, and your successors. Members will flock to us if you furnish valuable papers; and here, where so much that is novel in engineering is each year being brought out, you, whose brains furnish these novelties, should exert yourselves to put our Club, not in the front rank, it is there already, but at the head of all technical societies. It may be profit-

able to take a glance at what Philadelphia and Pennsylvania have already accomplished. Our State has just celebrated the centennial anniversary of the adoption of the Constitution of the United States in this city. The convention that completed the formation of a nation from a group of confederated states was invited to see the first successful steamboat move on the Delaware on August 22d, 1787. This was John Fitch's boat, which the next year plied regularly between Philadelphia and Burlington. In 1805 Oliver Evans ran a dredging machine from his shop at Ninth and Market Streets along the latter street, within a stone's throw of where you now sit, by means of its own steam, to the Schuylkill, from which place it paddled itself round to the point in the Delaware where it was to work, thus being the first locomotive in America. He had petitioned our legislature for the exclusive right to build steam engines as early as 1786.

Dr. Robins has shown us that the first permanent tramway in America was built by the ancestor of our member, Mr. Field, in our neighboring County of Delaware, in 1809. Though this was followed by some others of small size in other parts of the country, the first one on a grand scale was also in our State, that at Mauch Chunk, nine miles in length, finished in 1827. In 1828 surveys were made for a railroad between Philadelphia and Columbia. The chief engineer was Major John Wilson, the grandfather of our vice-president, who is to take the office of president to-night, who was so far seeing that he had the year before recommended a railroad rather than a canal; the assistant engineers were Henry R. Campbell, the uncle of our secretary, and Robert Pettit, the father of another of our members. So we see how closely our Club is connected with the earliest railroad engineers in the country. The Pennsylvania canals were built between 1826 and 1833, and three of their engineers, Wm. Strickland, Sam. H. Kneass and S. W. Roberts, have descendants enrolled as members of our Club. It was during those early Pennsylvania surveys that the engineer's transit was invented and made by Mr. Young of this city, an instrument now universally used by American engineers.

The modern railroad is considered to date from the locomotive trial on the Liverpool and Manchester Railroad in October, 1829,

when Stevenson's engine, the Rocket, carried off the prize. Before the news of this competition could have reached the United States, our honorary member, whom the growing infirmities of age alone prevent his attendance here to-night, Mr. Moncure Robinson reported on a railroad over the Allegheny Mountains and proposed using locomotives. He had seen the crude machines of that day at work in the colliery districts of England. Trevethick had constructed a locomotive in 1804 which made five miles an hour, using cog-wheels for adhesion, though they were not necessary. Stevenson's first locomotive had been tried in 1814, but it was only adapted to hauling heavy loads at a slow pace, four miles per hour, and he considered it only applicable to level roads; but Mr. Robinson saw its possibilities. He was connected with the construction of the canal, from Richmond up the James' River, in 1823 and 1824, but he advocated the advantage of a railroad over a canal, and because the State Commissioners were too conservative to follow him he resigned. The "Principal Engineer" of the State, under date July 1st, 1826, reported against a railroad and said: "In the making of a railway we have two things to consider, the *rails* and the *foundation.* The dimensions and strength of the rails are determined by the weight they have to support; hence the quantity of iron wanted is the same everywhere; but from an estimate I have seen, cast rails in England cost $62 a ton, delivered. Here, on the contrary, before delivery, they would probably cost at least $112, and their price might be advanced by a greater demand. So much for the iron.

"In regard to the foundation, it will be sufficient to enumerate its principal difficulties to give an idea of its considerable expense. For a double railway a road must be made about thirty feet wide; it must be graduated with mathematical precision, not inclining more than one-eighth of an inch to the running yard; it must not form abrupt curves, hence numerous deep cuts and expensive embankments; or, if these are not adequate to the object of avoiding great curvatures, expensive stationary engines and inclined planes must be constructed to carry the road in a direct line over such elevations as could not be graduated at the maximum angle which will allow the operation of the loco-

motive engine. Along cliffs, the railroad must be kept above high water, and held up by walls or paved banks, as expensive as along a canal.

"It must be carried over *every creek* by *stone* or *iron* bridges, which would be a serious cause of expense along the valley of a large river which receives a great many tributaries of all sizes, none of which should be suffered to reach the railway; whereas a canal may receive many of the minor ones. It is of the utmost importance that a railway should be dry and firm; this requires side ditches to drain it, and trenches filled with broken stones under the foundations of the rails; for this reason also, the expense of deep cuts would be increased by the difficulty of draining them, and that of embankments by the necessity of placing in their body masses of broken stones to act as sinks and prevent water being retained by them. If all these difficulties, and many others which it would be too minute to detail, are properly weighed, how could a railway cost less than a canal in a valley so broken and intersected by streams and drains as that of James River?"

The maximum grade mentioned by this gentleman of $\frac{1}{5}$ of an inch per yard, or about $\frac{1}{3}$ of 1 per cent., seems strange to us who do not hesitate to use grades of three times this amount in ordinary country, or even twelve times as much in the mountains.

In consequence, apparently, of the Principal Engineer's report, the canal was built, and it is interesting to note that more than fifty years afterwards the speaker was himself engaged in building a railroad up that very tow-path.

It is, perhaps, idle to speculate on what might have resulted in our country had Mr. Robinson's suggestions been followed.

Philadelphia had not yet lost her commercial supremacy, though the construction of the Erie Canal was fast taking the business to New York. It was still the financial centre of the country, as the United States bank had not yet failed. It retains only its manufacturing superiority. If, however, the connection had been made between the East and the West by means of a railroad in the James River valley, where but one summit was to be crossed to the waters of the Ohio, and a road could have been built, perhaps with grades as favorable as those on the New

York Central, twenty years before the lines forming the latter were built to Lake Erie, it might have exerted a controlling influence in the West. Had Virginia constructed such a link in those early days, who shall say how the destinies of the country might have been changed? She might have continued in the front as the most populous and prosperous of the States. Her enormous mineral wealth now being developed by so many of our members would have been sooner made available to the world, and the present wealth of New York and Pennsylvania might have been joined together within her bounds.

In the early development of the American locomotive, most of you know of the improvements which Philadelphia furnished through Mr. Norris, whose family is represented in our membership, and Mr. Harrison, whose technical library was generously given to the Club by his widow.

Let us now see how our State and City have taken the lead in bridge engineering. In 1796, in the western part of the State, the first modern suspension bridge was built by Finley. It was specially distinguished by having a stiffening truss. It was a chain bridge in which the links were "upset" at the ends, with iron of an ultimate strength of 60,000 pounds per square inch, and a factor of safety of $\frac{1}{4}$ to $\frac{1}{6}$ was used. It is extraordinary how scientifically this bridge was designed at so early a day. Finley afterwards built a bridge of 408 feet span over the Schuylkill, before the year 1808, near the present Laurel Hill steamboat landing, which was shown in an engraving which Mr. Graff once exhibited to the Club. The first *wire* suspension bridge was the one built by Chas. Ellet, a distinguished engineer from our neighboring County of Bucks, in 1841 and 1842, across the Schuylkill, where the present Callowhill Street bridge stands. In bridges, our city has always been foremost. The largest one of wood ever constructed was that which preceded Ellet's wire bridge, and was a wonderful example of framing when it was built in 1810. The first skew arch bridge built in the United States, with a series of square rings, was the Reading Railroad bridge at the Falls of the Schuylkill. The first wrought iron bridge posts used in the United States were in the Pennsylvania Railroad bridge at the Arsenal, since replaced with a stronger

structure. The first arch bridge hinged at the centre and the ends ever built, designed by our new president, carries the Pennsylvania Railroad tracks into the grain warehouse in West Philadelphia.

The cast iron arch at Chestnut Street, designed by one of our past presidents, is probably the finest example of that style of construction in the country, and one of the latest types of bridge, the cantilever, now spans the Schuylkill at Market Street, designed by one of our members. With the theory of bridge construction, too, our city was early connected. It is true that the first accurate method of calculating bridge stresses in trusses was published by Whipple, in 1847, in the State of New York. As he printed and sold his books himself in an interior town, it did not rapidly become known. In 1851, the father of our past president, Prof. Haupt, at that time connected with the Pennsylvania Railroad, published his work, not entirely complete, it is true, as regards the stresses on the braces, but a great advance over any other work, except Whipple's. Latham's book, in England, was not published until 1858, and Ritter's, in Germany, in 1863.

It has been suggested by one of our members that the Club should be somewhat more aggressive, and let the people of Philadelphia generally learn of what calibre its members are composed. This seems necessary from the fact that when experts are wanted by the city authorities to advise them on engineering subjects they go abroad for their advice. A few years ago the American Society of Civil Engineers was asked to recommend certain members from their body to report on a proper system of paving for this city. These gentlemen made an excellent report, but as they recommended an expenditure of $22,000,000, our Councils seem to have considered that Philadelphia was too poor a city to do things in a New York way, and little has been done toward carrying out the recommendations of the Board. As the expense was to be distributed over a series of years, costing $2,000,000 per year, and as after the fitting up of the Public Buildings there will be no need to tax the people $800,000 for that object, it is suggested that this amount be still collected and used each year for improving the streets. Though that will not

improve them as rapidly as the New York experts suggested, it will yet produce an immense change for the better, and a manufacturing city which requires so much hauling to advance its prosperity can save its citizens much more in wear and tear than the expense of the improvement. The city is not wanting, however, in proper knowledge as to how to bring it into a foremost rank. How to improve the water supply has been pointed out in the minutest detail by members of our Club, and if the City Councils can but divest themselves of their parsimonious ideas, they can be sure that the money asked for by the heads of departments will be expended as judiciously as possible, both with reference to economy and skill.

Among the great engineering works in progress throughout the world I can allude to but a few.

That which excels in magnitude any that is going on elsewhere is the Panama Canal. This is viewed with especial interest by Americans for several reasons. In the first place it is regarded as a work which should be exclusively American, and that no European government should have the credit and control of it in the event of its success. Again, although American engineers were invited to be present at a sort of advisory congress which was held in Paris at its inception, yet their recommendations were ignored, and a different route was adopted to that which their superior knowledge of the country pointed out as the best. As far as any political complications may arise, our countrymen are keeping very quiet. The cause is probably to be found in the conviction that the canal, as an open cut from ocean to ocean, will never be accomplished by the present company. When it has become bankrupt it will be time to acquire control. What annoys the American, however, is the great amount of money which is wasted in the present canal, which might have been so much better applied probably on the San Blas or other route. The collapse of the present company is as likely to produce as disastrous results to the finances of the French people as the famous South Sea Bubble or Law's Mississippi scheme to those of England. Even should a sufficient amount of wealth still be poured out to make the necessary cut through the mountains, the cost of maintenance would probably

preclude any profit arising from the traffic. The difficulty of controlling the Chagres River in times of flood does not seem to be sufficiently appreciated by the present management, and whether the immense dam for impounding the waters is finally adopted, or the cutting of a parallel canal to receive the surplus volume of a stream which rises in its banks sometimes forty feet in a single night, does not yet seem to be decided on by the authorities as far as can be discovered, though the control of these waters seems a vital element in the success of the canal.

Since the above was written it is announced that the Compte de Lesseps has at last given up his dream of a sea-level canal, and will overcome the Culebra pass by means of ten locks. Thus is the opinion of American engineers justified, and any advantage which the Panama route had over that by Lake Nicaragua entirely neutralized.

Among other works of magnitude it is satisfactory to note that the deepest foundations yet constructed are now being carried out by an American company which contained one of our past-presidents. The foundations of the Hawkesbury bridge in Australia, the building of which was obtained by Americans in the face of English competition, are about 185 feet deep below the high water surface. At such a depth compressed air, which has facilitated the construction of other very deep foundations, could not be used on account of its evil effects on the men, and a method of dredging inside caissons is being carried out, as far as is yet learned, perfectly successfully.

The largest railroad bridge in America has been designed by members of our Club, and will probably soon add another to the many triumphs of bridge skill across the Ohio. The Phœnix Bridge Company has designed a combined railroad and highway bridge of 550 feet span, exceeding by 30 feet or more the previous maximum truss railroad bridge in America. We have for a long time been able to boast of our exceeding great structures, surpassing, and usually far surpassing, those of other countries. Now, however, our English and Scotch cousins have awakened to the fact of our superiority and are constructing one of 1,710 feet span. This will exceed by more than 100 feet our own beautiful East River structure, and will like-

wise be designed to carry a heavier load, a modern locomotive and train. The plan is composed of cantilevers, now so popular a method of construction, and to an American eye has the proverbial English appearance of heaviness. It would be unsafe to say, without a laborious computation of the stresses, whether the appearance is intrinsic in the design. It is to be hoped, however, that it may soon become necessary to construct a similarly great bridge in the United States for an equal load, so that it may be seen whether an American design on even such a monumental scale will not retain the appearance of lightness, which to American eyes is so attractive, in spite of the English dogma, or heresy, that what is strong should look strong. On the contrary, it seems that when a structure that is strong looks weak it is a sign that the onlooker's eyes or judgment are at fault, and should be corrected to correspond with the truth.*

In conclusion, gentlemen, I have only to thank you for the great courtesy you have always showed to me, and to express the hope that your career will increase in prosperity as the years roll on, so that your reputation shall be national or even universal.

OPENING ADDRESS

OF

JOSEPH M. WILSON, President,

ON TAKING THE CHAIR FOR 1888.

Presented January 14th, 1888.

FELLOW MEMBERS:—I beg to thank you for the compliment you have paid me in electing me to the position of your President, and I trust that I may be able to show my appreciation of the honor and my deep interest in the Club, not only by giving my earnest attention to the duties which appertain to the office,

* An excellent location for such a long span bridge in the United States is between New York and Jersey City, and it is satisfactory that an American engineer has lately designed in all its details a bridge for that place of the unprecedented span of 2,850 feet, or more than 1,000 feet greater than the Scotch one. Let us hope that it may be speedily built.

but also by using my utmost endeavors to encourage whatever will tend to the Club's advancement and prosperity. I am very much afraid, however, that my efforts will suffer by comparison with those of my worthy predecessor, whose deep, earnest devotion to the welfare and progress of the Club and close attention to duties, have gained for him a reputation that it would be difficult to surpass.

A club of this kind has a wide field open to it, with great capabilities for good work, even greater in some respects than would, perhaps, obtain in a more prominent or more widely spread society, where the restrictions and responsibilities are increased. The young life, the liberality as to eligibility, the local interest and acquaintance among the members, and the freedom from the trammels that would encompass an older and more conservative organization, where the establishment of a precedent must always be considered, give greater opportunities and enable matters to be taken up and discussed in a way that would hardly obtain elsewhere.

There are numerous practical subjects of great importance and interest, not only to the engineer, but to the architect, the manufacturer or the citizen, that might be brought before the Club with advantage. Much of this kind of work has already been done, but cannot the usefulness of the Club be still further increased in this direction? For instance, there are local questions upon which a gratuitous opinion from among those best qualified to judge, might be of great benefit to the public. Papers upon the practical details of such matters as lighting by electricity, electro-motors, storage batteries, the heating and ventilating of buildings, sanitation, practical information on the locality and quality of the various woods, stones and other materials used in construction, and an almost endless variety of subjects, might be proposed for this purpose.

It would be an excellent thing to prepare a list of such subjects and to have it posted where all may see it, and from which selections could be made.

Members might hand in new suggestions from time to time, as they felt the want of information. These papers need not be long—the closer they adhere to the practical part of the subject the better.

The Club numbers among its members very many practical men in all departments of engineering, architecture and manufacturing, and its generous policy as to admission to its Associate class makes it just the place for such papers.

The Club has had a good past, it is in the tide of present success, and before it lies a great future, if it is properly developed and encouraged. My heart and hand are with it. Will you all join me in wishing it prosperity?

XXVII.

SOME NOTES ON RAILROAD CONSTRUCTION WHICH MAY BE OF USE TO ASSISTANT ENGINEERS.

By Theodore Low, Active Member of the Club.

Read April 2d, 1887.

When the Assistant or Division Engineer is placed in charge of any piece of railroad work, the first question brought before his mind is: how will I manage this work to the best advantage?

This question having arisen after a thorough inspection of the line or work to be performed, the next thing in order is to find the method sought for.

One source of annoyance, to say the least, is the number of *long* and *short* stations that often occur on the location turned over to the Assistant Engineer. These *long* and *short* stations are due to the number of necessary revisions of the first location; but instead of having the location broken during construction, the entire line, after all revisions have been made, should be re-run, by beginning the stationing of the line at the starting point and carrying the same enumeration through to the end.

The next step is the careful referencing of the points of curves and tangents, and all other necessary intermediate points. As many permanent sites as possible, such as church spires, edge of houses, trees, etc., should be selected for one point of the referenced line, and strong hubs, well driven into the ground, for the other points. The reference lines should cross each other, as nearly as practicable, at right angles; and care must be exercised that the

points so selected shall not be interfered with by construction, or of having a deep fill lie between the points, so as to cut out the line of sight between them; and to avoid many other sources of inconvenience resulting from carelessness in the referencing. A careful sketch of the position of the points, together with needle bearings, etc., should always be made.

Now comes the important work of running "check" levels over the entire division, and the establishing of benches. Knowing the sites where bridges, etc., are to be constructed, suitable benches must be established at those points. At other convenient places along the line, benches should always be placed as near the elevation of sub-grade as possible, owing to the convenience thus afforded.

A field book should now be prepared, having the left hand pages each divided into five columns. The first column for the stations, the second for the deflections, the third for the elevations, the fourth for the sub-grades, and the fifth for centre cuttings or fills, and the opposite pages for the sketches of reference points, remarks, etc., each in their proper place, thus having in one book all necessary information, in concise form, for the prosecution of the work. Where *long* and *short* stations unavoidably do exist, the same should be indicated in red ink; together with the distance, longer or shorter, or any other notes pertaining thereto, as it is an easy matter to overlook some of these points at times in running "grade" levels, retracing centre line, and in cross-sectioning.

Having prepared our field book, we start in on the cross-sectioning, or staking out of the work for construction. A Locke level will be found most expedient for this work, especially in hilly country.

After setting grade, cut and fill stakes, it is always wise to take the elevation of the ground for some distance beyond these points, as in cases where slips are likely to occur, or where the line of excavation has been extended beyond the slope stakes.

In all cuts of 15 feet or above, *distance* stakes should be set, that is, stakes with cut and distance from centre line marked thereon, should be placed far enough removed from the centre line, so as to be out of all danger of being disturbed by the possibilities mentioned above.

These stakes are valuable when it comes to the final cross-sectioning or measurement of actual work done, as it obviates the necessity of measuring from the centre line up some steep rock slope, which operation is often dangerous, not to say almost impossible, in some instances, when the cutting gets over 30 or 40 feet in height; and secondly, for the self-evident reason of the great saving of time.

In this connection, I may say that I devised a rod which I used to good advantage on some of my work on the Penna Schuylkill Valley R. R., at those places where the *distance* stakes had been accidentally destroyed by heavy blasting.

Out of well-seasoned pine I had a rod constructed, which was 16 feet in length, 1 inch in width and $2\frac{1}{2}$ inches in depth. This rod was graduated into feet and tenths. A level tube was inserted about 4 feet from one end, and a "bucket handle" also attached between the bubble and shorter end of the rod, in order to give a good leverage when holding the rod while measuring.

At the end farthest from the bubble, a roller was inserted, the outer circumference of which was "flush" with the end of rod. A piece of tin was then put on, encasing the end of rod and the roller, this to act as a "guide" for the tape line.

Standing on top of a rock slope you extend the rod, carefully leveling the same (having previously run the end of a 50-foot metallic tape line between the casing and roller, and to the line attached a plumb-bob), you let the tape unwind slowly until it touches the "grade" beneath, then, noting what it reads at the end of the rod nearest to you, deduct the length of the rod and you have the perpendicular height or cut. Then, finding the point where the plump-bob struck the "grade," add to or subtract from the length of the rod, if the point is to in or out of centre line, thus getting at the same time the horizontal distance out, in addition to the perpendicular height.

A record of cross-sections should also be kept, in case the field book should become lost or destroyed. All cross-sections should be plotted in a regular cross-section book, manufactured for that purpose. The area of each section should be calculated and set down with the section. These areas, in many cases, will serve for the monthly estimate and can therefore be put on the "detailed"

estimate blanks as soon as calculated and the cubic yards gotten, thus facilitating the monthly estimate.

We will now proceed to stake out a bridge.

If over a river, or other expanse of water, making it impossible to get the distance from one abutment to the other by the ordinary means of measuring with steel tape line, select a place along the shore, convenient for a base line, for your triangulation. The point I wish here to impress is, that too great a care cannot be exercised in regard to getting the *true* length of the *base line.* The various angles may have been gotten with the accuracy of precision, while the base line has only been given ordinary attention.

This line should be, at least, as long as the distance between abutments, or where this is impracticable, no one angle of the triangle should be as great, or greater than a right angle. Having now selected your site for a base line, the true measurement from "hub" to "hub" is, of course, a measurement taken on a level plane, and not by stretching your tape from two pivot points, as there is surely always a "sag" in the middle of the tape. As it is never your good fortune to get a natural level place for your base line, you will have to proceed to manufacture one, as it were. Drive in stakes, carefully leveling each with the other, say every 25 feet (more or less if necessary), and then place strips of boards on these, nailing them securely in place. Now, on measuring along these strips, you get a measurement as nearly correct as it is possible so to do.

Where a steel wire is used to get measurements, instead of by triangulation, the same care must be exercised, so that the wire will show the exact length or distance desired. Measure your base line with the same care as described, then suspend your wire, both ends of which are in the same level, between the two extremities of the measured line. Have one end of the wire attached to a reel and the other to a common spring scale. Then gradually pull on the scale until the wire swings clear of the ground and a reasonable amount of "sag" has been taken out. Note the number of pounds pull indicated on the scale. Then, by means of plumb-bobs suspended over both points of the base line, define the points on the wire corresponding with the points of the base line.

After determining these points, have a small piece of lead soldered on to mark the places. A small cut or scratch on the lead will define the exact point.

Everything now being ready, stake out the abutments, etc., and reference them securely. The neat line at foundation of both face and wing (if there be the latter) should be referenced, as this will save considerable time when foundation points, neat points, etc., are desired. All reference points about bridges should be protected in some manner at least, by putting a sort of a triangular trellis around each hub, thus serving as a signal to workmen to stand aloof. At the same time judgment should be exercised in placing the points only in such places where they will not be likely to interfere with the work of the contractor, as the latter class abominate the idea of "treading on eggs."

Having everything staked out, work begins on the same for the purpose of getting a good foundation.

In ordinary work a good coffer-dam only is required to successfully excavate without danger or loss. But how often even good contractors fail when it comes to this kind of work, it would be hard to determine, therefore a word of caution is not amiss:

The contractor, generally paying the expenses of coffer-damming, has his own way as regards the building of the same, and as a result, no attention being paid to the weight likely to be brought to bear against it and corresponding strain, it breaks in, and more time and money are lost than would have more than paid for its proper construction in the first instance. I would suggest that where water, silt, sand, etc., are likely to be encountered, no stick of timber with a face less than 10 inches by 12 inches should be used for stringers or braces in a single dam, and no less than 2-inch oak plank for sheeting.

These dimensions will be found to be factors of safety in nearly all cases having the same conditions as those spoken of, yet they are merely given as a guide to those who do not desire to enter into the intricacies of calculations concerning the moment of resistance in substances.

Where there is a proximity of running water, it is scarcely safe to build on material other than solid rock, or very compact and uniform gravel. In the latter case it is well to go deep

enough, so as to avoid the possibility of scouring or underwashing.

Where a foundation of rock, or hard, uniform gravel cannot be obtained, where the foundation is correspondingly hard and soft, a good layer of concrete, from 2½ feet to 3 feet, should always be put in, providing that there is no trouble in keeping the coffer-dam dry, as in the latter case only can concrete be laid as it should be; yet I would never advocate the use of timber in abutments, notwithstanding.

Concrete cannot be too well made, neither can it be too rich in cement. I have found the following mixture to make an exceedingly "*sure*" concrete: 4½ parts stone (broken so as to pass through a 3-inch ring), 1½ parts sand and 1 part cement, the latter being of the ordinary brands found in the market. In the mixing of concrete the greatest care should be exercised. Mix, first, the cement and sand together, dry, so that the mixture will have a uniform color. After wetting the stone, spread the mixture of sand and cement over the former in alternate layers; then, by means of a hose, introduce water, and mix the whole mass thoroughly by means of shovels and pitch forks, always working from the outside to centre of mass. In ramming concrete, do not cease until the mortar oozes from the top and runs flush over the whole concrete.

Where the foundation masonry is laid upon the natural surface, it should be laid "dry," and the stones should all be headers. All interstices should be filled with stone well broken in, all exposed joints "pointed," and then the whole thoroughly grouted. The remaining courses should be laid in cement mortar and also grouted.

In regard to the masonry of piers, particular attention should be given to the building of the "nose" or ice-breaker. Where any danger from ice, drift wood, etc., exists, all stones in "noses" of piers should have a large bearing surface, each stone "butting" well against the other and leaving no interstices. In addition, each stone should be well clamped to the other by iron clamps. As a further precaution against ice, etc., all masonry in running water should be thoroughly rip-rapped, the more, the better.

In arch culvert masonry and retaining walls, after a good foundation, the liberal use of grout will be found beneficial. Care should be exercised in filling in behind arches and retaining walls. When filling behind arches the material should be of broken stone, carefully placed, and evenly brought up on both sides, so as not to exert an undue pressure from one direction. The same care should be taken in filling back of retaining walls.

All fills of 10 feet in depth, or greater, should be made from ½ foot to 1 foot higher than sub-grade at the centre or deepest part of the filling, and then gradually run to grade at mouth of cuts, on either side. A good, wide bank is always desired, as the heavy rains soon play havoc with them. Fills should always be made in horizontal layers, each layer having the full required width, for, as in those cases where the fill has not been made to the full width, it is a difficult matter to widen them afterwards in some kinds of material, as the last layer will always be found to "run."

All earth cuts should have a "berm" ditch about 10 feet back of top of slope, for the preservation of the latter. All wet earth cuts should be ditched at the foot of slope also.

It is also better to break all slopes, excepting rock, by making them 2 : 1 on top, for a depth of 2 to 10 feet, thus relieving the top weight and aiding materially in the protection of the same.

During construction, a "progress" profile has now been considered almost a necessity.

In reference to track-laying, one or two points to be guarded against are the kinking of rails; the use of coal dirt, or other unsuitable material as ballast, which is likely to cause trouble during the winter by freezing.

In elevating the outer rail on curves, use 1 inch of elevation to every degree of curvature up to and including 5 degrees, then ½ inch to every additional degree up to 12 degrees. Gradually elevate the rail at the rate of 2″ per hundred feet when approaching point of curves, until the full elevation is reached at that point. From point of tangents, diminish elevation in same ratio.

In conclusion I would suggest, that to be successful as an Assistant Engineer is to be systematic in management, far seeing, and familiar with even the smallest details of the work.

XXVIII.

THE GILEPPE DAM.

By A. Marichal, Active Member of the Club.

Read October 15th, 1887

In the eastern part of Belgium, within nine miles of the German boundary, is a town named Verviers, having for main industry the manufacturing of woolen goods. All the water needed by its active population was drawn directly from a creek running through the city. Unfortunately this creek had a very irregular current, and many times all the factories had to stop working on account of want of water.

The idea of building a storing reservoir came to the mind of everyone. The City Government, together with the State Government, made appropriations to the amount of $1,200,000, and work was begun in 1867. A masonry dam was thrown across the valley in the upper part of the creek; an aqueduct 5¼ miles long and 50 square feet in sectional area was constructed with a view of discharging 46,000,000 gallons per twenty-four hours.

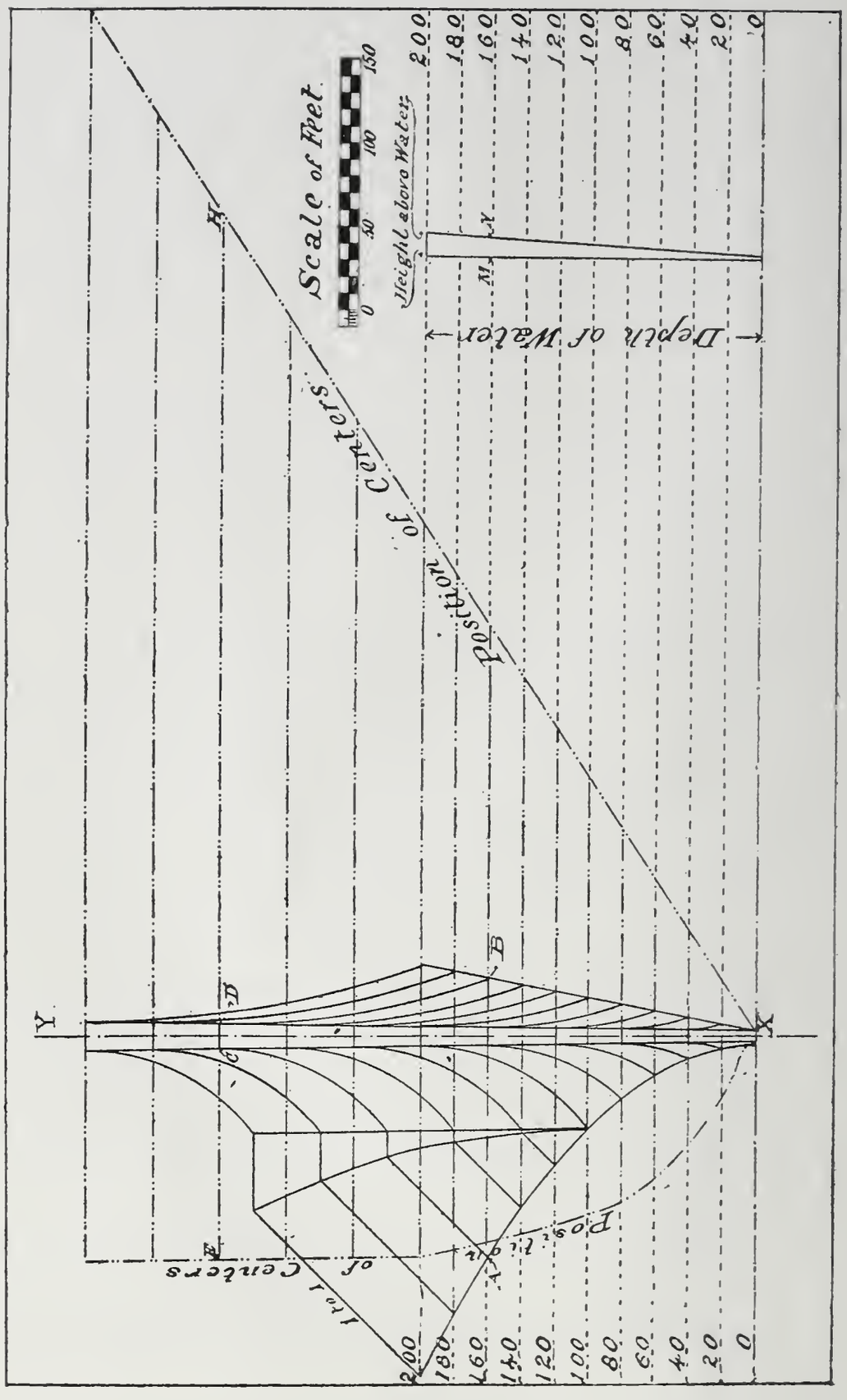
In 1879 the work was completed and, to the great satisfaction of the inhabitants, a constant supply of water was furnished to them at the trifling cost of ¾ cent per 1,000 gallons. The water, being distributed under pressure of 100 to 120 pounds, is used by many as a motive power for running their machinery. It is almost entirely free of lime, and by this fact can be used in the different preparations of wool.

A few figures relating to this great work will be of interest, I suppose. The storing reservoir covers an area of 200 acres; its capacity is equal to 3,173,000,000 gallons. The dam is curved in plan, with its convex side towards the up stream. The radius of the curve is 1,532 feet. This dam is 49.2′ wide at the top and 216′ at the bottom.

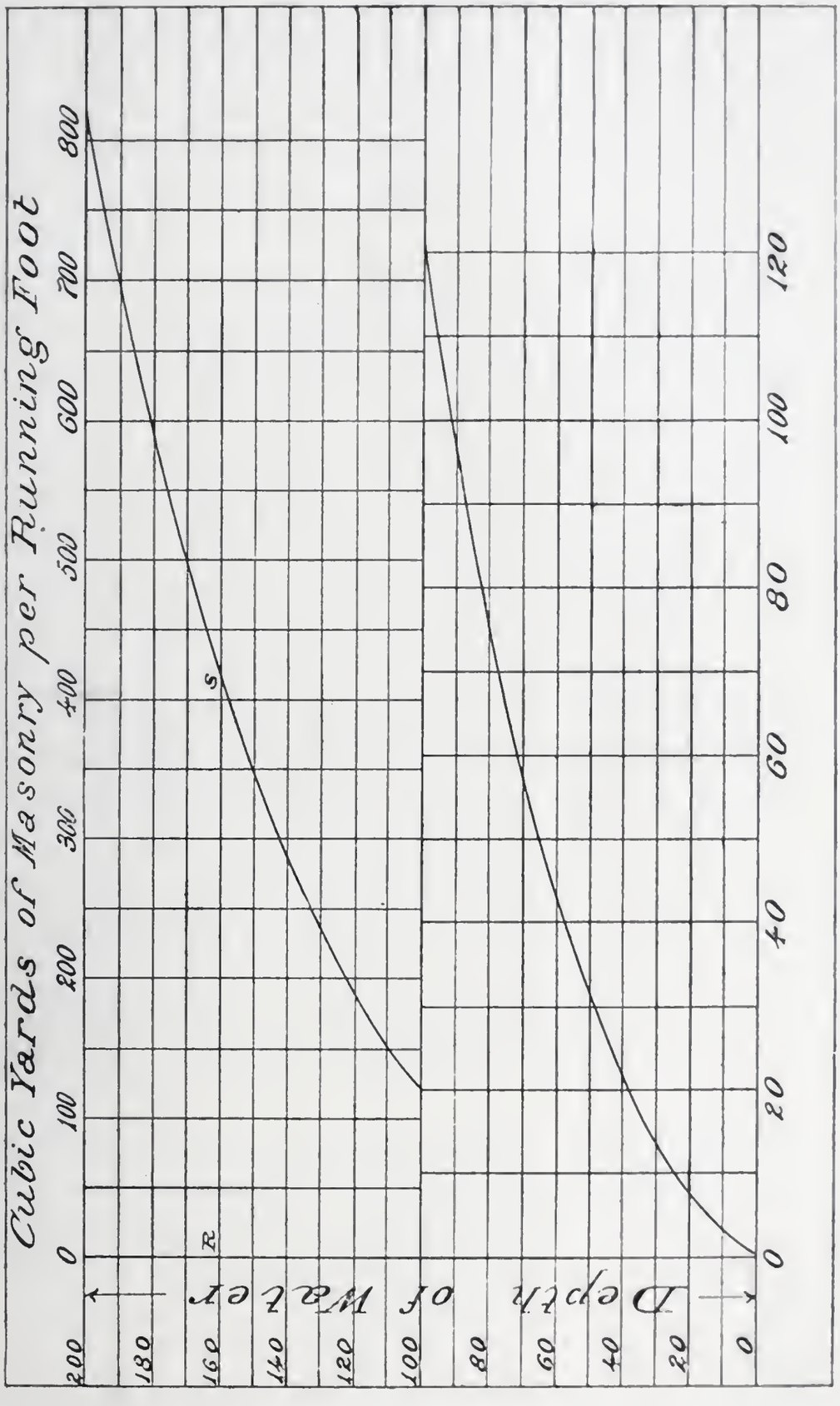
Its total height is 156.6′; there are 325.036 cubic yards of masonry, representing a weight of 531,481 tons. It is rubble masonry, laid in good hydraulic mortar, and weighing 1.75 tons per cubic yard.

On top of the dam, and in its centre, an immense statue, representing a lion, has been placed. This lion is made out of 183 pieces of sandstone; its height is 44.28′; with pedestal, 70.52′. The head is 227.12′ above the bed of the creek. The body is

PLATE


Scale of Feet.
0 50 100 150
Height above Water
Depth of Water
Position of Centers
Position of Centers
Y
X
H
D
C
B
M
N
200
180
160
140
120
100
80
60
40
20
0

6.


Cubic Yards of Masonry per Running Foot
0
100
200
300
400
500
600
700
800
Depth of Water
0
20
40
60
80
100
120
0
20
40
60
80
100
120
140
160
180
200
R
S

16.4′ wide and 52.5′ long. One of the claws measures 5.31 feet in length. The diameter of the tail is 3.28′, and the length of the nose 8.20′.

The dam, although very thick, is leaking; about 23,000 gallons of water are filtering daily through this immense wall. It is believed that this filtration will cease, that the pores of the material will be filled by the different substances in suspension in the water. In fact, this filtration is diminishing in intensity, but very slowly.

Plate No. 1, annexed to this paper, shows on the left side the profile of the Gileppe Dam as it is constructed, and on the right side the profile for a similar dam when constructed according to diagram and formulæ, also annexed (Plate 6). It will be seen that a saving of 50 per cent. masonry could have been made by using the profile of the diagram; that, without making either the leverage stability, or the frictional stability in any way too small, the granular stability would have been increased considerably. The defect in the Gileppe Dam is that the centre of gravity of the section falls too near the upper stream toe. If some day they want to make the wall higher by 20′ or 30′, as it has been contemplated, the centre of gravity would be shifted still more towards the very same toe, and the dam would become entirely unsafe, having to sustain a maximum *computed* pressure of 12 tons, or more, per square foot, when 6 to 8 tons, according to the quality of masonry, is all that should be allowed in work of that kind.

Plates 2, 3, 4 and 5 show similar comparisons with other dams. It will be seen at a glance that the profiles given by the diagram are not superseded even by profiles designed by the most prominent engineers.

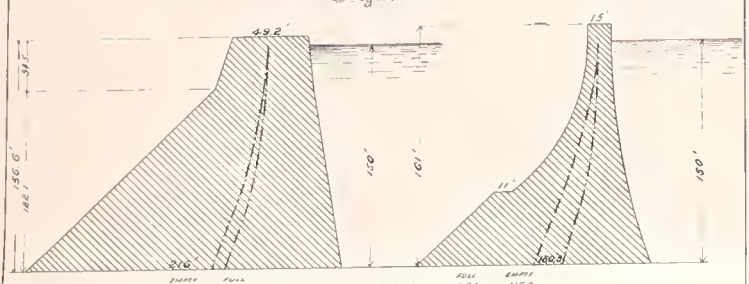
I have heard of some objection against curved profiles; that the trouble to build them would not compensate the saving of masonry. I would answer that, from practical experience, I may state that it does not take more time for a mason to build a wall of curved section, provided that the engineer in charge has laid out the work decently. I do not think that an engineer, taking charge of a work, should throw away thousands of dollars belonging to his employer, for the sake of avoiding a little trouble.

NOTE.—The figures given on the annexed plates should not be taken as absolute but purely as relative, viz.: for comparison. They will hold good for masonry, weighing from 1.7 to 1.9 tons per cubic yard.

The Gileppe Dam

— Belgium —

1

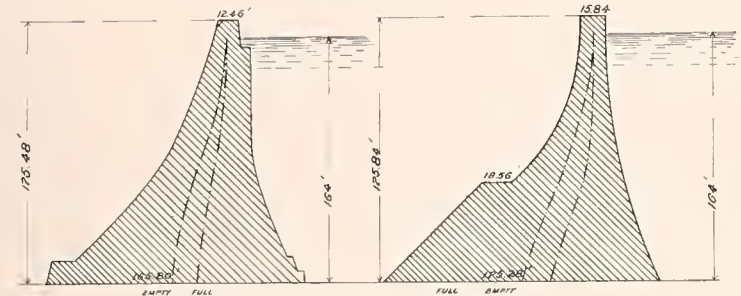


Empty	Full		Full	Empty
37.60	10.90	Leverage Stability	4.20	11.60
21.66	2.60	Frictional "	1.42	10.83
4.60	4.73	Granular "	8.13	6.00
2.0	2.0	Amount of Masonry	1.00	1.00

The Furens Dam

— France —

2

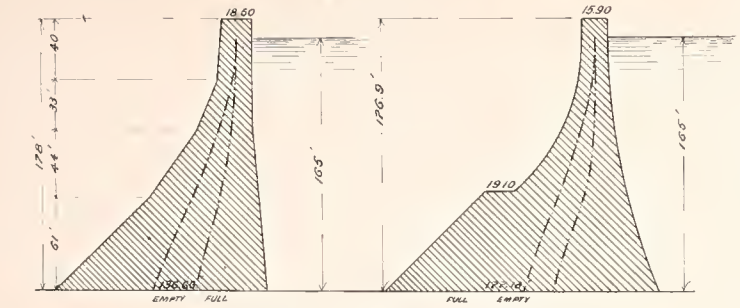


Empty	Full		Full	Empty
188.4	4.40	Leverage Stability	4.49	153.2
125.0	1.48	Frictional "	1.46	125.0
5.80	6.35	Granular "	7.70	6.0
1.00	1.00	Amount of Masonry	1.00	1.00

The Quaker Bridge Dam

— New-York —

3

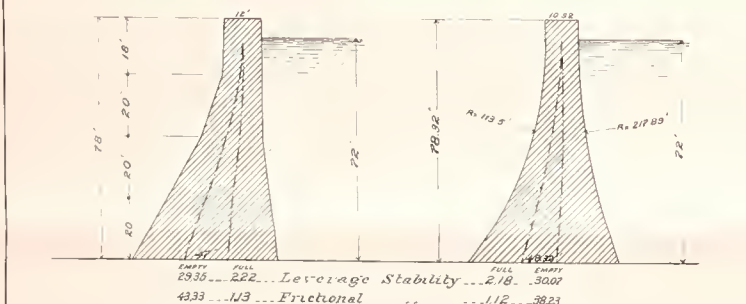


Empty	Full		Full	Empty
85.00	9.00	Leverage Stability	4.50	153.3
106.4	1.17	Frictional "	1.46	125.2
4.10	5.67	Granular "	7.72	6.01
0.85	0.85	Amount of Masonry	1.00	1.00

The Sodom Dam

— New-York —

4



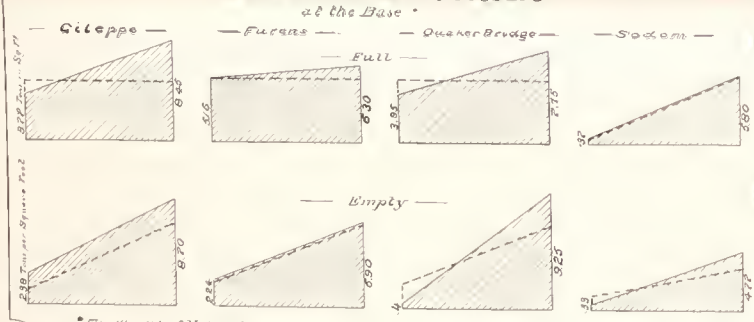
Empty	Full		Full	Empty
29.35	2.22	Leverage Stability	2.18	30.07
43.33	1.13	Frictional "	1.12	38.23
8.39	6.90	Granular "	7.00	11.99
1.13	1.13	Amount of Masonry	1.00	1.00

Diagram showing

The Distribution of Pressure

at the Base *

5



* The Weight of Masonry is supposed to be 1.7 T. per Cub Yard

Note. By adopting the Profiles of the annexed Diagram the Pressure would be as shown by Dotted Lines. (see Plate 6)

XXIX.

THE PLAN FORMATION OF THE QUAKER BRIDGE DAM.

By A. Marichal, Active Member of the Club.

Read January 14th, 1888.

I think it is unnecessary to call the attention of the members of this Club to the importance of the subject. The proposed Quaker Bridge Dam is well known to you; its feasibility, its necessity is beyond any doubt.

This dam will be the greatest work of the kind in the world. It will be another triumph of engineering to be added to the credit of the American genius. The plans are made; the work may begin at any time.

But a question is raised: Shall this dam be constructed on a curve or on a straight line?

In a report to the Aqueduct Commission the engineers in charge do not hesitate to say that the straight dam so far exceeds in strength, economy and safety the curved one, that they recommend the adoption of the former.

This report will be the topic of my discussion, and I would like it to be understood that I do not intend to criticise the work of the experienced engineers in charge of this great undertaking. What I want is to show some mistake in their theory and in their practical deductions, leaving to you to judge whether I am right or wrong.

Before entering the discussion I wish to say that, on the 3d inst., I wrote to the author of the report and informed him of my intention to refute his theory at this meeting, with invitation to be present.

The report says: "No masonry bridge arch of over 300 feet span has been constructed. Beyond that length of span the crushing strain sustained by the voussoirs exceeds safe limits or their mortar joints from the weight of the masonry alone, without the added load the bridge should carry. It would therefore be out of question to construct a masonry bridge of the length of Quaker Bridge Dam (1,350 feet long), as it would be over four times the limit of safety in a possible span. The arch of a

curved dam, however, does not carry any part of its own weight (as in the case of a bridge); therefore its strength of arch will bear only the water pressure against it from a full reservoir."

I will answer that the stability of a bridge arch can not be compared with the stability of an arch acting horizontally; that not only the latter has not to carry any part of its own weight, but that this weight forms an additional stability; consequently, that its strength of arch *will not bear the total water pressure* against it, but *only the difference* between said pressure and the resistance produced by the weight of masonry.

Going again to the report, the Engineer says:

"I have worked out a formula and used it for the calculations on curved dams: Supposing $R =$ the radius of the curve; $W =$ the weight of water pressure on a belt of the dam, one foot in breadth and the length of the chord; $C =$ the length of the chord; $P =$ the total pressure on a voussoir joint, which, divided by the area of the joint, gives the average pressure per square foot; then $P = \frac{W R}{C}$." By that formula the engineer calculates that a strain of 46.8 tons per square foot would be sustained by the voussoir joints (for $R = 900$), and calls attention to the fact that said pressure will increase as the radius increases.

I think that his formula has but one defect; it is too mathematically correct. If I would like to be as mathematically correct, I would have to use the very same formula to prove that it is a mistake to build a dam on a straight line. In fact, according to the formula and the engineer's own statement, the pressure increases as the radius increases; if we suppose the radius infinite, as in the case of a straight line, the pressure becomes infinite, and the dam will be pulverized.

This would be an absurdity; it shows to you the fallacy of a purely theoretical conception. The formula, nevertheless, is correct, but wants a practical interpretation. Then (P) is not the pressure on the voussoir joint, but the force that should be applied on it to make equilibrium to the water pressure; and in the case of a straight dam, the force is not applied, it can not be applied. If the wall itself does not resist, the dam must fail. The formula referred to would be true for an ideal dam, without any thickness, offering no resistance whatever; the reaction of the

hill sides would have to offer the total resistance. But as soon as you jump from pure theory into practice, you are compelled to give some thickness to the structure, and no matter how thin it is, it will offer some resistance to the horizontal thrust of the water, and *only the excess will be equilibrated by the reaction of the abutments.* It is consequently evident that, as long as this reaction does not reach a certain limit of safety, the curved shape adds to the stability.

In fact the report acknowledges this additional stability, since I find in it the following statement relating to the Zola Dam: "The thickness of masonry is so small that the resultant falls outside the front toe, and that (unless the excellence of its mortar and generally of its masonry be exceptionally great) its stability is due to the fact that it is built in the form of an arch, the water pressure being transmitted to the abutments. Moreover, the form of its section shows that the intention of its designer was that it should act so."

I will say that the *water pressure is not transmitted to the abutments,* but *only the excess of pressure not carried by the wall itself.* Nevertheless the additional stability of the curved shape, which the designer says he fails to see, is proved by his own description of the Zola Dam. Moreover he says, in speaking of straight and curved dams, that both plans have been followed with *successful results,* and out of 23 dams described in his report 15 are curved and one is 762 feet long, with a radius of over 1,600 feet.

But the engineer says that only one of these curved dams is acting as an arch—it is the Zola Dam. That the other ones are gravity structures and cannot act as arch; that their curved form must weaken their stability. I wish to know who could explain the logic of his argument; if the dam does not act as an arch, how can it be imagined that the curved form will weaken its stability! If these curved dams could tell you how many times the reaction of the abutments did relieve them from undue strain oppressing their stability, then you would apologize.

You state the fact that curved dams have always been made strong enough to resist the water pressure by their own weight. I will say that it was very wise to do so; it prevents that the failure of a part would cause the failure of the whole.

In the case of the Quaker Bridge Dam, let us see what would

be the additional stability. We have to find how much the pressure on the curved dam could be increased without trespassing the limits adopted by the engineer in designing the profile of his wall. They are as follows:

Limit for crushing strain: 16.63 tons (2,000 lbs.); minimum factor of safety against overturning: 2.07; minimum resistance to sliding: 0.597.

The pressure of the water is the same on any part of the arch at a fixed depth, and is normal to the extrados. Consequently there is no reason why we should not admit that the pressure will be uniformly distributed on the voussoir joint, since in this case, like in the designing of the section, the factors of safety are there to meet the tolerable irregularities in the workmanship.

We have to find what pressure of water would allow 16.63 tons per square foot to be transmitted to the abutments. The resistance offered by the wall is, first, the friction; and considering the wall to be made of dry rubble, the coefficient of friction would be .7, and we have

$$P = \frac{2\,(H - .7\ W)\ R}{D\ B}$$

in which P = maximum pressure per square foot on a joint; H = horizontal thrust at water of a given depth; W = weight of masonry above joint; R = radius of curve; D = depth of water; B = depth of voussoir joint.

We find that the pressure of the water should be increased by 56 per cent. to allow 16.63 tons per square foot to be carried to the abutments. If no sliding takes place, an elastic movement may happen, the wall may bend. There again the weight of masonry will be a resistance, and the pressure that will possibly be equilibrated by the reaction of the abutments will be given by the formula:

$$P = \left\{ \frac{H - \frac{M}{L}}{D\ B} \right\} R$$

in which M = momentum of resistance produced by the weight of the wall; L = distance of centre of pressure above joint; B = depth of voussoir joint at the top. The elasticity of the masonry cannot be ascertained with any degree of accuracy, but I agree with the author of the report—it is insignificant; and neglect-

ing it, we find that the water pressure should be increased by over 200 per cent. to allow 16.63 tons to be transmitted to the abutments. This figure can only be taken as a limit, since the profile is somewhat elastic, and what we may say with certainty is, that the additional safety resulting from the curved shape is between 56 per cent. and 200 per cent. Calling it 100 per cent., we are sure to make no exaggeration, since the cohesive power of the cement, which has been neglected entirely, exists nevertheless. And it is really an additional safety; because, admitting that 16.63 tons to the square foot is transmitted to the abutment, we find by calculation that the granular, the frictional and the leverage stability are still above the fixed limits of safety. What will be the cost of these 100 per cent. of additional stability? Only 13 per cent. of the cost of the dam.* When we come to think about the terrible consequences which would follow the failure of this immense construction, we are led to recommend the introduction of this cheap coefficient of safety.

It is needed; I will prove it hereafter. The designer says that the maximum crushing strain in the wall will be 16.63 tons per square foot, and acknowledges the fact that this figure is much above the limit adopted by French engineers in constructions of the kind. He says, further, that the formula deducted from Sazilly's trapezoid of pressure, which is generally adopted and which he has used, "indicates pressures larger than they are in reality; that the profiles based on that method show an excess of strength which gives a further guarantee of safety." I have to say it is a mistake; the formula

$$P = 2\left\{2 - \frac{3\,U}{L}\right\}\frac{W}{L}$$

$$\text{or} \qquad P = \frac{2}{3}\frac{W}{U}$$

according as U is greater or less than $\frac{L}{3}$

is based on the hypothesis that masonry is absolutely rigid, but it is not, and, according to Mr. J. B. Francis' views on the subject, which views are in accordance with mine: "Although the work

* With a radius of 900 feet the amount of masonry would be increased by 3 per cent.; but ordinary rubble masonry being not fitted to sustain lateral strains, 10 per cent. should be added for extra care in the workmanship; thence 13 per cent. extra cost.

may be done in the best manner possible, it will yield a little to the pressure, and the amount of compression in different parts will be unequal and nearly proportional to the pressure and depth of the mass of masonry at its different parts." According to this theory, the maximum pressure in the Quaker Bridge Dam would be 21 tons per square foot, and it is evident that the true theoretical pressure must be between the limits of 16.63 and 21. Consequently the formula *does not indicate in this case larger pressures than really exist, but smaller ones;* and this is the theoretical pressure which, in either case, supposes that there is a uniform bearing surface, homogeneous, giving the full benefit of its entire area. I will say that in assuming that you would polish the bearing surface of all your stones, you would not yet succeed in making the area effective in all its parts.

The limit assumed by the designer is evidently too high; his profile is weak, he shows it himself. Comparing it with dams in existence, it is found to be the weakest one; comparing it with profiles of dams conceived by reliable authorities, it is found to be one of the thinnest sections ever proposed. His mathematical calculations may be correct, they will not be proved by practice. Of course the wall may resist, but in this case it is too much of a risk to run.

I conclude that the dam wants an additional factor of safety, and the cheapest one is certainly realized by the introduction of a curved plan.

With 13 per cent. extra cost you give 100 per cent. more stability to the structure.

Think about the Puentes Dam, which gave way in 1802, killing 600 persons, destroying over 800 dwellings, and you will have an idea of the danger you will face if you fail to take benefit of any additional safety offered to you at so low a rate.

From an engineering point of view the adoption of the straight dam would be very regrettable; it would be the sanction of a false theory.

There was some discussion by Mr. J. E. Codman, who defended the plan of the dam, quoting abstracts from the report of Chief Engineer Church, from *Engineering News* of January 14, 1888, p. 20.

ANNUAL REPORT OF THE SECRETARY AND TREASURER,

For the Fiscal Year 1887.

Presented January 14th, 1888.

To the Officers and Members of the Engineers' Club of Philadelphia:

Gentlemen:—I have the honor to present the following statement of the receipts and expenditures for the fiscal year from January 8th, 1887, to January 13th, 1888, both inclusive.

Howard Murphy, Secretary and Treasurer, in account with
The Engineers' Club of Philadelphia.

Dr.

Balance on hand, Jan. 8th, 1887,		$365 19
Initiation Fees, Active,		155 00
Dues, 1883, Non-resident,	$5 00	
" 1884, Resident,	7 50	
" " Non-resident,	4 74	
" 1885, Resident,	22 50	
" " Non-resident,	18 62	
" 1886, Resident,	42 50	
" " Non-resident,	62 50	
" 1887, Resident,	1450 50	
" " Non-resident,	589 75	
" " Associate,	15 00	
" 1888, Resident,	691 50	
" " Non-resident,	265 50	
" " Associate,	15 00	
" 1889, Resident,	5 50	3196 11
Sales of Proceedings, Authors,	1 14	
" " Members,	7 25	
" " Non-members,	9 00	17 39
Advertisements, 1883,	4 00	
" 1884,	32 00	
" 1885,	84 00	
" 1886,	396 00	
" 1887,	12 00	528 00
Subscriptions to Volume VI,		15 00
Postage on Proceedings,		12
Balance from old Reception account, from C. E. Billin,	63 03	
Subscriptions to Decennial Reception,	358 00	421 03
		$4697 84

Cr.

Rent,		$1000 00	
Gas,		47 45	
Coal-oil for Janitor,		4 80	
Coal, Small Stove,	$80 25		
" Egg	46 25		
" Chestnut	11 00	137 50	
Janitor,		240 00	
Ice,		18 25	
House Expenses,		20 90	
Repairs,		10 44	1479 34
Salary, Secretary and Treasurer,			1000 00
Proceedings, Vol. V, No. 4,		6 38	
" " VI, " 1,		171 15	
" " " " 2,		192 08	
" " " " 3, on account,		6 75	
" " " " 4, " "		45 67	422 03
Reference Book,			12 99
List of Members,			80 00
Notices and Records of Meetings, and Elections,			106 17
Miscellaneous Printing and Stationery,			66 99
Postage,			187 86
" due,			30
Messenger and Express service,			1 40
Key deposits returned,			75
Book binding,			5 25
Insurance on furniture, etc.,			22 50
Furnishing,			85 22
Decennial Reception, on account,			540 04
Contribution to Executive Board of Council of Engineering Societies on National Public Works,			100 00
Sundries,			52
Balance, cash on hand, January 13*th*, 1888,			586 48
			$4697 84

The following are the closely approximate assets of the Club, in addition to its library and furniture:

Cash Balance Jan. 13th, 1888,	$586 48
Due from Members to end of fiscal year 1887; initiation fees and dues,	828 26
Due for advertisements,	339 00
" Proceedings, etc.,	18 80
	$1772 54

The $45.67 expended on account of Vol. VI, No. 4, belonging to 1888, will probably balance the excess of cost of VI, 3, now in press, over the advertisements.

My report, that it may correspond with the Cash Book, shows that the expenditures on account of Decennial Reception amount to $540.04, while it shows the receipts on that account to amount to but $421.03. This apparent deficit of $119.01 in that account will be covered partly by subscriptions not yet paid in and the balance will be provided without drawing upon the treasury of the Club. It (the $119.01) should, therefore, be added to above assets, making an aggregate of $1791.55. The current quarter's gas bill, to date, would amount to about $9, and so our net assets are $1782.55. Subtracting from this the advance dues received to date, $977.50, we have a net balance of $805. A similar balance last year was given at $830, which makes it look as if we had become $25 poorer, but the fact is that we anticipated our balance and voluntarily contributed $100 thereof to the Executive Board of the Council of Engineering Societies on National Public Works. Had we not done so, we would have been able to show $75 increase—instead of the above trifling decrease—in our financial worth.

MEETINGS.

Regular, ...	12
Business, ...	5
Total, ...	17

ATTENDANCE.

	1887.	1886.
Members, total, .	449	479
" average, .	26+	27—
Visitors, total, .	23	20

There was one more meeting in 1886, no meeting having been held on December 17th, 1887, which was the Decennial Anniversary of the Organization of the Club, and was celebrated by the holding of a Reception in the Club House. This reception was attended, the hat and coat checks indicate, by 342 members and guests, and the expense thereof, $572.17, has been provided for without drawing upon the treasury of the Club.

Continuing the Membership table from my last Report (Vol. VI, No. 2, p. 135), we have

	HON.	COR.	ACT.	ASSOC.
Membership at end of fiscal year 1886, .	3	5	451	9
Additions, ...			30	2
			481	
Deceased, ...	1		1	
			480	
Resignations, etc., ...		5	18	
Present Membership	2	0	462	11

The net increase in Active Membership has been about $2\frac{4}{10}$ per cent.

The residence of our Active Membership is now as follows:

Philadelphia, . .	221	Minnesota . . .	2
Pennsylvania, outside of Philadelphia, .	96	Michigan, . . .	2
New York, . . .	34	Iowa, ...	2
New Jersey, . . .	19	Kentucky, . . .	2
Virginia . . .	16	Tennessee, . . .	2
Colorado, . . .	8	Kansas, . . .	2
Missouri, . . .	6	Maine, ...	1
Illinois, . . .	6	Rhode Island, . .	1
Massachusetts, . .	5	Indiana, . . .	1
Ohio, . . .	5	Idaho, ...	1
District of Columbia, .	5	Arizona . . .	1
Delaware, . . .	4	U. S. Colombia, . .	1
Connecticut, . .	3	Austria, . . .	1
West Virginia, . .	3	Japan, ...	1
Texas, ...	3	India, ...	1
Maryland, . . .	2	New Zealand, . .	1
North Carolina . .	2		462
Alabama . . .	2		

The Active Members residing within the County of Philadelphia are, therefore, in the minority by 20.

We have lost but two members by death during the year—the

venerable Thomas U. Walter, Honorary Member, and Frank Maddock, Active Member, who had just entered his early prime.

Nothing that might be said of them could add to the respect and regard that all who knew them have for their memory.

The following Papers, etc., have been presented during the year:

The Centrifugal Pumps at Mare Island Navy Yard, California, by Mr. Henry R. Cornelius.

Hydraulic Dredging Machinery, by Mr. Conway B. Hunt.

Controlling Expansion in Locomotives, by Mr. W. E. Hall.

The Anderson Process of Water Purification on a Large Scale, by Mr. E. S. Hutchinson.

The Proposed Improvement of the Harbor of New York, by Prof. L. M. Haupt.

The Tensile Strength of Canvas, by Prof. L. M. Haupt.

The Differential Gauge as Used at Blast Furnaces, by Mr. Morris P. Janney.

The Effect of Saccharine Matter on Mortars, by Mr. Morris P. Janney.

The Increased Weight of Locomotive Engines as Affecting the Strains on Railway Bridges, by Prof. L. M. Haupt.

The Mechanical Genius and Works of the late Sir Joseph Whitworth, by M. John Fernie (Guest).

A Fixed Nozzle Automatic Injector, by Mr. Strickland L. Kneass.

The Manufacture of Cement in the United States and the Growing Demand for High Class Mortars, by Mr. R. W. Lesley.

3 ins. vs. 4 ins. Thick Steel Tyres, by Mr. Theo. J. Lewis.

The Large Engines to Drive the Centrifugal Pumps for Reclaiming the Potomac Flats, Washington, D. C., by Mr. A. P. Broomell.

An Ice Machine, by Mr. A. P. Broomell.

Phosphor-Bronze Wire for Helical Springs, by Mr. Wilfred Lewis.

Screw Threads, by Mr. John L. Gill, Jr.

A Rail Chair, by Mr. H. H. Sintzenich (Guest).

The Clapp-Griffiths Steel for Structural Work, by Mr. F. H. Lewis, with Discussion by Mr. Percival Roberts, Jr.

Maps for Railroad Surveys, by Mr. Emile Low.

Notes on Railroad Construction, by Mr. Theo. Low.

The Prevention of the Spreading of Fires, by Mr. F. W. Whiting.

A Stamp Splice, Tongue and Groove Rail Joint, by Mr. Francis Lightfoot (Guest).

Petroleum, by Mr. Max Livingston.

Notes on the Preparation of Anthracite Coal, by Mr. Edwin Ludlow.

A Perpetual Motion Machine, by Mr. J. E. Codman.

Some Remarkable Breaks in a Reservoir, by Mr. Lewis N. Lukens.

River and Harbor Maps, by Capt. S. C. McCorkle, with Discussion.

The Retardation of the Tide in the Vicinity of Philadelphia, etc., by Capt. S. C. McCorkle.

A Multiplication Table, by Mr. W. L. Hoyt.

Should the Custom of Upsetting the Ends of Bridge Bolts be Abandoned, by Mr. John L. Gill, Jr.

The Construction of Reservoir Walls, by Mr. Arthur Marichal, with Discussion by Messrs. J. E. Codman, Frederic Graff and Howard Murphy.

A Diagram for the Regulation of Dimensions, etc., of Cast Iron Flange Pipes, by Mr. J. E. Codman.

Fire-Resisting Paint, by Mr. Edward Hurst Brown.

A Safety Self-Extinguishing Car Stove, by Mr. R. Meade Bache.

The Strength of Irregular and Composite Structures. General Discussion.

A New System of Screw Threads, by Mr. John L. Gill, Jr.

A Venetian Ship Railway, by Mr. E. L. Corthell.

Camp Life on the Union Pacific Railway Surveys, by Mr. C. H. Middleton, Jr.

The Susquehanna River Bridge of the Baltimore & Ohio R. R., by Mr. S. P. Mitchell.

A Boat Telemeter, by Mr. R. Meade Bache.

The Carnell Air Injector, by Mr. J. M. Cameron (Guest).

A Traveler to Carry Wires, Ropes, etc., through Conduits, by Mr. Henry G. Morris.

Experiments with Current Deflectors at Five-Mile Bar, Philadelphia, by Prof. L. M. Haupt.

The Gileppe Dam, Belgium, by Mr. A. Marichal.

Connections for Secondary Batteries, by Mr. A. Saunders Morris.

Tests for Riveted Joints, by Mr. W. H. Nauman.

Water Filtration, by Mr. Henry Roeske (Guest).

Boiler Specifications, by Mr. C. G. Darrach, with Discussion by Messrs. J. T. Boyd, C. T. Thompson, A. Marichal, J. E. Codman, O. C. Wolf, P. Roberts, Jr., G. R. Henderson and Howard Murphy.

The Calorimetric Investigation of the Performance of a Compound Engine, by Mr. W. H. Nauman.

Cement Tests, by Mr. J. E. Codman, with Discussion by Mr. A. Marichal.

A Specimen of Cement, by Mr. C. H. Haswell.

The Palmetto Railroad, by Mr. P. T. Osborne.

The Unaccountable Deficiency in the Track of American Railways, by Mr. R. B. Osborne, with Discussion.

Respectfully submitted,

HOWARD MURPHY, *Secretary and Treasurer.*

NOTES AND COMMUNICATIONS.

EFFICIENCY OF DIFFERENT FORMS OF BOILERS IN USE BY THE PHILADELPHIA WATER DEPARTMENT.

REGULAR MEETING, NOVEMBER 20TH, 1886.—Mr. John E. Codman presented an account, illustrated by blackboard sketches, of the results obtained from recent tests. The boilers first tested were four in number, and known as "double-decked," a popular form in Philadelphia, and supposed by many to be an economical steam generator. The lower boiler generally contains about as many tubes as the tube sheet will safely hold; the upper boiler, or drum, is connected to the lower one by two or more necks, and the water is usually carried so as to half fill the upper drum. In the trials mentioned, the height of water was measured from the bottom of the upper drum. For 16 hours it was kept at 5½ inches from the bottom, and for 8 hours at 12½ inches from the bottom. This difference is not very great, but the results obtained show the advantage of keeping the water as low as possible in the upper drum, as, with high water, much that is obtained is only apparent evaporation. An apparent evaporation of 16,000 pounds of water was obtained per hour for the four boilers, which, when corrected, gave only 16,700 pounds per hour. The calorimetrical tests for quality of steam, made at intervals of 30 minutes, gave over 8 per cent. of water in the steam.

With 5½ inches in the upper drum, an apparent evaporation of 16,100 pounds was obtained per hour, which, when corrected for steam, etc., gave 17,230 pounds per hour. The calorimetrical tests gave 6¼ per cent. of water in the steam. The evaporation of water per pound of combustible averaged above 9⅓ pounds for the 24 hours. Using

$34\frac{1}{2}$ pounds of water from and at 212° Fahrenheit as the equivalent of a horse power, the low water gives 500 horse-power, against 486 horse power for the higher water. The coal used was an ordinary quality of Schuylkill pea coal, containing about $16\frac{1}{2}$ per cent. of ashes and clinkers. The second tests were made on the ordinary tubular boiler, set in brick-work and externally fired, arranged so that the escaping gases passed over the top of the boiler and around the steam drum. The boilers were run for 24 hours, all water and coal being carefully weighed and checked at the end of each hour; the dampers were kept wide open, and all the coal that could be burned upon the grates, with a natural draught in a chimney 60 feet high, was put into the furnaces. The calorimetrical test gave very good results, the average of thirty-nine observations showing $\frac{247}{1000}$ of one per cent. of water in the steam. The evaporative efficiency of these boilers was $10\frac{1}{3}$ pounds of water per pound of combustible. The rated horse power of the boilers was 30 horse power for each, or 60 horse power for the two tested. The horse power developed, using $34\frac{1}{2}$ pounds of water from and at 212° Fahrenheit, was nearly 100 horse power.

Some discussion followed. President Washington Jones said: In the so-called "double-decked boilers" the contracted passages or necks, connecting the upper and lower sections, and through which the steam formed in the lower section rises to the upper one with such a high velocity as to carry entrained water, this water passes to the steam pipe and is credited as steam, unless the calorimeter test reveals its presence.

This disposition to carry water is augmented by the increased velocity of the ascending steam, caused by the injudicious crowding of the tubes nearly to the top of the lower section, and by insufficient space between the vertical rows, so that the passage ways through the necks are thereby obstructed. The better practice is, to omit such tubes as come immediately under the necks, leaving a space of several inches (say one-half the diameter of necks) between the shell at necks and the adjacent tubes, so as to obtain a more quiet liberation of the steam bubbles. The necks should be of limited diameter, ordinarily from 10 to 14 inches, so that the strength of the shell shall not be impaired by the holes cut in it to match the necks. More than two necks are injurious, as the upper and lower sections should not be rigidly bound together, but should be permitted to alter their parallelism, if unequal expansion demands it. The greater quantity of steam formed at the front, or furnace end, of boiler should establish a circulation upwards through the front neck, and downwards through the back neck. This, however, is evidently not the fact, as the quick and frequent fluctuations of the water line, shown by the glass gauge, proves. When a volume of steam, greater than usual, is generated in the front end of boiler, the quickened ascent of the current causes a larger quantity of water to flow through the front neck into the upper section, and the water-line rises momentarily at that end of the section, and is so shown by the glass water gauge; meanwhile, the water is passing down the neck at back end. When the ebullition at front end becomes quieter, and the upward current slower, the water-line falls to a level, or possibly below it, at front end, if the back neck is giving a passage to steam formed at back end of boiler, and so reverses the currents. One requisite of the first importance to the evaporative efficiency of a boiler, is the production and maintenance of a constant current of water, passing, without change of direction, over the heated metal surfaces, so as to sweep off the steam bubbles adhering to those plates, and bringing into their place fresh particles of water to be, in their turn, converted into steam bubbles.

ANALOGIES BETWEEN ELECTRICAL AND MECHANICAL UNITS AND PHENOMENA.

Business Meeting, December 4th, 1886.—Mr. Carl Hering read the paper. After explaining why electrical quantities cannot be expressed in the ordinary mechanical units, he stated that the only units which were alike, or interchangeable in the two systems, where those of *time* and *energy*. The others, although not interchangeable, are quite similar, in their nature and their effect, to certain mechanical units. Electrical quantity expressed in coulombs has no equivalent, but quantity flowing per second, or current, expressed in ampères, is analogous, in most respects, to a current of water, and it follows most of the laws governing the latter. Electrical pressure, or electromotive force, is analogous to mechanical pressure, or to water-motive force, as it might be called when referring to water. In both it is that which causes a current to flow, and without which no current can flow. A great pressure exists similarly in a friction electric machine and a fired pistol; in both it will overcome great resistances; in either case, if it readily overcomes the high resistance of the human body, it becomes dangerous.

The zero-level of pressure of electricity is taken as that of the infinitely large quantity of electricity in the earth, just as the zero-level of the water is that of the ocean, or the normal pressure of air is that of one atmosphere. The terms positive and negative pressures, or currents, may be applied similarly to all these three cases, assuming the zero or normal levels as explained. It is not known whether electricity flows at all, but for all practical purposes it may be supposed to do so. The "earth return" circuit used in telegraphy, in which the two ends of a wire are connected to the earth, was compared to a single pneumatic tube, the two ends of which communicated with the open air, or an "air return circuit," thus showing that the electricity does not necessarily flow back through the earth.

Resistance is similar in both. Self-induction may be compared to inertia, being the apparent resistance to a sudden stopping or starting of a current. The increased electrical pressure at breaking a circuit is analogous to that in the hydraulic ram. Electrical work, which is pressure multiplied by quantity, is equivalent to foot pounds, as of a quantity of air at a certain pressure. In both cases, if the pressure is high, the quality of the work or the effect will be analogous; similarly, if the quantity is great; the discharge of a pistol is analogous to that of a Leyden-jar, and an air blast or a wind analogous to incandescent lighting currents. Similar analogies exist with power, as in a watch and a telegraph current. An Edison telephone consumes about one thousandth of the power in a watch. The power of a bolt of lightning is said to be equivalent, in some cases, to the work of a 100 horse power engine for 10 hours. The discharge of a small Leyden-jar is about one two-thousandth of that of a small pistol. A series of arc lamps is represented quantitatively by a series of water-falls, each 50 feet high, discharging 45 gallons per minute; a set of incandescent lamps, by a single fall of 100 feet, divided into small falls, each of 4 gallons per minute.

Generators of electricity, or dynamos, do not produce electricity; they are analogous to a pump or an air-blower, in which *pressure* is generated, but not *quantity* of electricity, water, or air. Similarly, a storage battery does not store electricity, but pressure. The current, passing through them, stores its pressure, similarly to the storing, in the steam, of the heat of the gases in a boiler.

ABSTRACT OF MINUTES OF MEETINGS.

Continued from Vol. V, No. 4, page 363.

Of the Club.

April 3d, 1886.—Regular Meeting.—President Washington Jones in the chair; 22 members and 2 visitors present.

The evening was spent in an interchange of views as to how to best promote a more extended *discussion* of the numerous subjects brought before the Club. Various methods of bringing the original papers to the early attention of members likely to discuss them were proposed. The subject was finally referred to the Publication Committee.

April 17th, 1886.—Regular Meeting.—President Washington Jones in the chair; 27 members and 1 visitor present.

Mr. J. S. Elliott presented a discussion of the recent paper by Mr. C. W. Buchholz upon "Engineering; Its Achievements and Its Reward."

Mr. H. W. Sanborn made some remarks on Recent Stream Gauging for the Future Water Supply of Philadelphia.

Mr. E. V. d'Invilliers spoke upon the geological position, characteristic features and method of mining the ore at the Cornwall Iron Mines, Lebanon Co., Pa., illustrating his remarks with several maps and cross-sections, and a relief model of the mines and contiguous territory, constructed by Mr. A. E. Lehman.

Mr. A. E. Lehman then exhibited, and described the method of construction of, the Model of the above mine.

May 1st, 1886.—Business Meeting.—Vice-President Thomas M. Cleemann in the chair; 22 members and 1 visitor present.

The Tellers of Election, Messrs. J. E. Codman and W. J. Hoyt, reported that 116 votes had been cast, and the following elected Active Members of the Club: Messrs. John Rowbotham, Wm. N. Howell, Max H. Biernbaum, Gratz Mordecai, Henry M. Sperry, A. G. Menocal, James W. Leahy, Otto C. Wolf, N. H. Culver, Capt. J. C. Mallery, Frank S. Brock, A. P. Kirtland and Thomas H. Dobson.

The Publication Committee, in the matter of devising means to encourage and increase the discussion of papers read before the Club, reported progress.

Dr. H. M. Chance read an illustrated paper upon the Pressure and Composition of Natural Gas in Pennsylvania.

Mr. Frederic Graff presented Notes Upon the Early History of the Employment of Water Power for Supplying the City with Water, and the Building and Rebuilding of the Dam at Fairmount.

Mr. T. Earl Collins offered the following mathematical question: Does a locomotive piston at the end of each stroke, in reversing its direction, come to a stand-still, and if so, can the same be mathematically demonstrated?

Also, would a difference in speed affect the duration of its stationary condition, if such exists?

Mr. Collins suggests: "As the crank pin describes a circle, changing, at every point, its direction, and therefore having, at all times, more or less lateral movement, and its movement being continuous, it is argued that the piston can have no moment of rest without the crank pin coming to rest also, supposing perfect joints."

Mr. A. R. Roberts exhibited a working model of a device to reduce the wear on level crossings, at angles from 70° to square, to a minimum, and also the wear of wheels and axles passing over such crossings, to a minimum, by making a pratically continuous bearing for both tracks, and obviating the necessity for any wheels to have to jump a frog throat. The whole appliance for closing the gaps is operated from the signal tower.

May 15th, 1886.—Regular Meeting.—President Washington Jones in the chair; 28 members and 3 visitors present.

Mr. E. S. Hutchinson read a paper giving a Résumé of the Report of the Hon. John Bigelow on the Panama Canal made to the New York Chamber of Commerce.

Dr. R. P. Robins, introduced by Mr. T. M. Cleemann, read an interesting account of the First Permanent Tramway in America, which was projected by Mr. Thomas Leiper, of Delaware County, Pa., in 1809, for the transportation of stone.

Dr. Robins' description contains full quotations from various historical authorities, contemporaneous newspapers, etc. A vote of thanks was extended to Dr. Robins for his very entertaining contribution.

Prof. L. M. Haupt exhibited an original drawing of Josiah White's, containing designs for Dams Nos. 3 and 4 on the Lehigh. They were built of round timbers, filled with rip-rap, and were each about 36 feet high. Mr. White is known as the inventor of the earliest form of movable dam, known as the "Bear Trap," which he built at the mouth of the Lehigh, at Easton, in 1818.

Prof. Haupt also presented some extracts from a paper on the Phila. Traction Co.'s Lines by Mr. H. R. Stoops, wherein a comparison is made between the cable and horse systems of street railways, favorable to the latter. Remarks were made by Mr. Henry G. Morris on an Electric Motor Car, and by Mr. John T. Boyd on Traction Cables and Machinery.

The Secretary announced the death of our fellow member, Mr. E. F. Loiseau, in Belgium.

June 5th, 1886.—Regular Meeting.—President Washington Jones in the chair; 30 members and 1 visitor present.

Mr. J. E. Codman presented a paper on Calorimetric Tests of Boilers.

The Secretary presented, for Mr. G. R. Henderson, an article on the Taper of Steam Jets, issuing from circular orifices.

Mr. Henderson acknowledges the assistance which Mr. W. E. Hall rendered him in making these experiments.

Mr. A. Marichal, introduced by the Secretary, presented a mathematical discussion of Question No. 3, as to whether or not the piston of an engine comes to an absolute rest at the end of its stroke.—Mr. Marichal claims that it does.

The Secretary presented, for Mr. B. Ayres, of Philadelphia, an old-time profile of Section 34 of the Gettysburg Extension of the Penna. R. R. System, 1838. It was drawn by Mr. W. Hazel Wilson, the Chief Engineer. After $1,000,000 was expended on the road, the State abandoned the work.

Mr. Ayres' contribution also included a copy of General Profile of the Northern Pacific R. R., and one of the Bozeman Pass Tunnel on that road.

A vote of thanks was returned to Mr. Ayres for these contributions to the library.

The Secretary presented, for Messrs. Wilfred Lewis, M. R. Mucklé, Jr., and Coleman Sellers, Jr., Chairman, the Committee appointed for that purpose, a memorial notice of the late Theodore Bergner. A history of his life and labors, and an account of his principal inventions, are given.

The Secretary presented, for Mr. P. D. Ford, a large number of corrections to Nystrom's Engineers' Pocket Book, which the author thought to include all in the first half of the book. It was thought desirable that these corrections should be placed in the hands of members, especially if the correction of the book could be made complete; and the Secretary was directed to correspond with Mr. Ford and with Messrs. J. B. Lippincott & Co., the publishers, on the subject.

The Secretary exhibited the map of the First Permanent Tramway in America, which was described by Dr. R. P. Robins at the meeting on May 15th, 1886.

June 19th, 1886.—Business Meeting.—President Washington Jones in the chair; 21 members and 1 visitor present.

The Tellers of Election reported that 101 votes had been cast, and that the following had been elected Members of the Club. *Active:* Messrs. J. S. Walker, Hiram J. Slifer, Richard B. Osborne, G. L. Jones, Geo. Henderson and B. H. Wright. *Associate:* Mr. E. V. Douglass.

The Secretary presented a Report from the Publication Committee, to whom was referred the matter of providing additional facilities for the discussion of papers, wherein the Committee recommend no departure from our present methods. On motion, the report and recommendations were adopted.

The Secretary presented, for Prof. L. M. Haupt, the following:

"Whereas, It is proposed in the U. S. Senate to add an item to the River and Harbor Bill amounting to One Million Dollars, for the purpose of beginning the work of improving the entrance to New York Harbor in accordance with the specific plan, approved by a Board of Engineers as stated in Ex. Doc. No. 78, House of Representatives, 48th Congress, 2d Section, and

WHEREAS, The plan as proposed involves a large expenditure of time and money, and is uncertain in its results, and

WHEREAS, We believe the limitation of the expenditure to a specific plan would not produce the desired end in the most expeditious manner; it is therefore

Resolved, That in view of the great importance of radically improving the entrance to the harbor of New York, in the most expeditious, economical and effective manner, we would respectfully request our Honorable Senators and Representatives in Congress to urge the appropriation of the amount desired, but only on the condition that its application be not restricted to any special plan, but be opened to all competitors, upon plans to be subject to the approval of the Chief of Engineers, or of a Board of Engineers to be appointed by him."

With reference to the motion to adopt the Resolution, Prof. Haupt called attention to the uncertainty, expense and great length of time which would be required to carry out the plan of the stone dyke from Coney Island, and stated that he believed the result would be merely to create a second contraction, similar to that existing at the "Narrows," with deep water at the exit, but that beyond there would reform a bar with not more than the present depth of water. The plane of tidal scour is limited, at that locality, to 24 feet, and unless some device be used to maintain an increased *bottom* velocity at ebb tide, he predicted failure. The dyke would violate a fundamental principle of harbor construction, by opposing great resistance to the flood wave, and hence diminish and weaken the ebb discharge, causing a shoaling in the lower bay and a cutting off and destruction of the northern channels. It would also render existing "aids to navigation" (lighthouse, etc.) useless.

He reaffirmed his opinion as to the practicability of utilizing the forces, acting so powerfully at the head of Gedney's Channel, to open and maintain the same, and believed it should be attempted by other means than by dykes or by dredging, before Congress committed itself to the plans proposed.

On motion of Mr. E. S. Hutchinson the Preamble and Resolutions were unanimously adopted.

The Secretary presented, for Mr. H. K. Lee, a table of Sizes of Chimneys, for the Reference Book.

The Secretary presented, for Mr. Fred. Brooks, C. E., of Boston, Correspondent, a table of Approximate Metric Equivalents, for the Reference Book.

The Secretary presented a letter from Capt. Spencer C. McCorkle, wherein he states that the Superintendent of the U. S. C. & G. Survey had given his assent to the presentation to the Club, for publication and discussion, of the investigation which Capt. McCorkle has made of Movement of Ice in the Delaware River in 1886.

Capt. McCorkle was present and explained the scope of the paper, and specially desires free and full discussion thereof.

Mr. Gratz Mordecai, author of a report on Railroad Terminal Facilities at New York, presented "Notes on the Investigation of the Movement of Freight and Passengers in Cities," and exhibited a large map—about 6′ x 10′—showing New York City and surroundings from Eighty-sixth Street on the north to Erie Basin on the south.

The Club adjourned for the summer, to meet at the call of the chair.

October 2d, 1886.—Regular Meeting.—President Washington Jones in the chair; 31 members and 1 visitor present.

Prof. L. M. Haupt read some extracts from a paper by Mr. Milne, Institution of Civil Engineers, entitled, "Construction in Earthquake Countries," with its discussion. The results were obtained from careful seismic surveys made in Japan, and led the author to state that the safety of a building depended primarily upon its inertia, and secondarily upon its foundation being made "free," either by using a bearing of cast iron shot, or of troughs filled with sand. A peculiar phase of earthquake phenomena, not hitherto observed, was the much greater disturbance at the surface of the ground over that at the bottom of a pit only ten feet deep. As to the site of a building, solid and high ground was always to be preferred.

Prof. Haupt also exhibited some photographs of Mr. J. Lesley Corbett's Improvements in Solar, Mining and Engineers' Transits, which he has so ably adapted to meet the numerous and complicated requirements of the various sub-divisions of the pro-

fession. This instrument, which is at once stadia, graduator, transit, alt-azimuth, solar and level, was made by the Messrs. W. & L. E. Gurley, Troy, N. Y., in 1883–4.

Mr. Oliver B. Harden read a paper upon Photographic Map Reduction—the method employed by the 2d Geological Survey of Penna., on account of its accuracy, quickness and cheapness as compared with other methods of reduction.

The Secretary presented, for Mr. John Graham, Jr., an illustrated description of the Horizontal Turbines at Willimantic.

The Secretary presented, for Mr. W. E. Hall, a Review of the Freight Brake Trials.

October 16th, 1886.—Regular Meeting.—Past-President Frederic Graff in the chair; 23 members and 1 visitor present.

Mr. J. E. Codman presented an illustrated description of a case of Low Water in a Steel Boiler, wherein the refilling of the boiler, after the exposed portions had reached a high temperature, produced no evidence of a tendency to crack in the steel.

Mr. C. O. Hering presented Tables of Equivalents of Units of Energy and Equivalents of Units of Weights and Measures, for the Reference Book.

Mr. J. H. Harden read a paper on Early Mining Operations in Berks and Chester Counties, Pennsylvania.

Mr. William E. Lockwood, introduced by the Secretary, gave a brief description and review of the progress made in the efforts to determine the "Hammer Blow" of a Locomotive's Drivers, since January, 1883, when Mr. Lockwood spoke on the subject of the Shaw locomotive before the Club. Stereoptical views were shown of the Ashtabula Bridge before and after the accident, the conditions stated, and the suggestion made that the "hammer blow" might have been the cause.

Next were shown views of the Dudley Dynograph Car, including the machinery by which the conditions of the track are determinated, and a sample sheet showing the results.

Three views followed of a New Application of the Dynamometer for determining the "hammer blow" of a locomotive's drivers. A description of the dynamometer was read and explained.

Following these were shown the coupling pins and pulling bar, which attaches the tender to the locomotive, it being claimed that these demonstrated in their "wear and tear" the difference between the present system of "rotating counterbalance" and "steam self-balancing counterbalance."

Three views were then shown of appliances recently constructed to prove, as Mr. Lockwood states it, "that the top of the driving wheel, when the bottom is in contact with the rail, moves twice as fast as the bottom, and that the bottom stands perfectly still."

November 6th, 1886.—Business Meeting.—President Washington Jones in the chair; 12 members and 1 visitor present.

Messrs. H. J. Hartley and A. Saunders Morris, the Tellers of Election, reported that 105 votes had been cast, and that the following were elected Active Members of the Club: Messrs. Louis S. Wright, G. D. Chenoweth, Albert Millet, Wm. D. Hewitt, A. E. Harvey, Jr., H. A. Schofield, Amasa Ely and Arthur Marichal.

The Secretary presented, for Mr. W. E. Hall, a paper on Car Lubrication. Some discussion followed by Prof. L. M. Haupt, Mr. John T. Boyd and others.

Mr. Frank A. Hill presented a paper on Fatal Accidents in Anthracite Mines.

The Secretary presented, for Mr. Geo. R. Henderson, a paper on the Efficiency of Locomotives and Resistance of Trains.

The Secretary presented, for Mr. Herman Haupt, Jr., a description of the St. Paul Ice Palace, illustrated by photographs and prints.

November 20th, 1886.—Regular Meeting.—President Washington Jones in the chair; 15 members present.

The Secretary presented, for Mr. George R. Henderson, a Table of Millimetres and Equivalents in Inches, for the Reference Book.

Mr. John E. Codman presented an account, illustrated by blackboard sketches, of the results obtained from the recent tests of the Efficiency of Different Forms of Boilers now in use by the Philadelphia Water Department.

Discussion followed by President Washington Jones.

The Secretary announced the death, on October 7th, 1886, of Mr. Frank S. Brock, Active Member of the Club.

December 4th, 1886.—Business Meeting.—President Washington Jones in the chair; 24 members present.

Nominations were made for Officers to serve during the fiscal year 1887.

Mr. Carl Hering read a paper upon Analogies between Electrical and Mechanical Units and Phenomena.

The Secretary presented, for Mr. A. H. Howland, a paper upon the general subject of Water Pipes.

Some discussion upon the Water Pipe question followed, by Mr. W. J. Hoyt, Prof. L. M. Haupt, Mr. C. T. Thompson and the Secretary.

The Secretary presented, for Mr. Rudolph Hering, notes upon the Present Investigation of the Drainage and Water Supply of Chicago.

The Secretary announced the death, on November 6th, 1886, of William Brantley Cooper, Active Member of the Club, and read, from the *Washington County Advertiser*, of Fort Edward, N. Y., an interesting account of his life and work.

December 18th, 1886.—Regular Meeting.—President Washington Jones in the chair; 22 members and 1 visitor present.

The Secretary presented, for Mr. Kenneth Allen, a table of Thicknesses of Plates for Stand Pipes, with formulæ, for the Reference Book.

Prof. L. M. Haupt presented the results of some calculations upon the Equilibrium and Stability of his system of Floating Deflectors.

The Secretary presented, for Mr. A. H. Howland, a paper upon Stand Pipes.

The Secretary presented, for Mr. J. H. Harden, notes upon the Chester Co., Penna., Granite, illustrated by specimens and photographs.

January 8th, 1887.—Ninth Annual Meeting.—President Washington Jones in the chair; 40 members present.

The Retiring President, Mr. Washington Jones, delivered the Annual Address.

The Secretary and Treasurer presented his Annual Report for the fiscal year 1886.

On motion of the Secretary and Treasurer his accounts for 1886 were referred to the Finance Committee for audit.

The Tellers of Election, Messrs. Wilfred Lewis and John S. Mucklé, reported that 165 votes had been cast, and that the following were elected Active Members of the Club: Messrs. Arthur Falkenau, Theodore L. Welles, Sydney W. Arnold, J. J. Tierney, Benjamin Franklin, James M. Dodge, S. S. Evans, W. S. B. McCaleb, Edward H. Brown, Alexander Wurts and Robert A. Shillingford; and that the following had been elected:

OFFICERS FOR 1887:

President—Thomas M. Cleemann.

Vice-President—Joseph M. Wilson.

Secretary and Treasurer—Howard Murphy.

Directors—John T. Boyd, C. W. Buchholz, Frederic Graff, Washington Jones and M. R. Mucklé, Jr.

President-elect Thomas M. Cleemann took the chair with appropriate remarks.

The resignations of the following from Active Membership, which had accumulated during the year, were accepted: Messrs. T. E. Collins, H. S. Drinker, J. D. Estabrook, W. P. Gerhard, F. W. Gordon, H. Hoopes, W. N. Howell, J. R. McClure, Jos. Mercer, I. W. Morris, G. B. Price, C. A. Rutter, G. C. Thomas, A. M. White and E. A. Wilson.

Mr. Henry R. Cornelius read a paper relating to the two large Centrifugal Pumps at Mare Island Navy Yard, California.

On account of the lateness of the hour, the other papers announced for the evening were deferred till next meeting.

JANUARY 22D, 1887.—Regular Meeting.—President T. M. Cleemann in the chair; 25 members and 1 visitor present.

The Secretary presented, for Mr. Conway B. Hunt, a paper on Hydraulic Dredging Machinery.

The Secretary presented, for Mr. W. E. Hall, a paper on Controlling Expansion in Locomotives.

Mr. E. S. Hutchinson described the Anderson Process of Water Purification on a Large Scale.

The Secretary had announced, in the notices for this meeting, that he had received from the New York Chamber of Commerce a few pamphlets upon the Harbor of New York, with circulars inviting discussion of the proposed government work on the Harbor, and that they would be mailed, on application, to such members as are specially interested in river and harbor improvements, or desire to examine the documents with a view to possible discussion of the special questions involved in New York Harbor.

In compliance with the request embodied in the circular, Prof. L. M. Haupt entered upon a discussion of the subject.

Prof. Haupt also submitted results of tests of the Tensile Strength of Canvas, for the Reference Book.

February 5th, 1887.—Regular Meeting.—President T. M. Cleemann in the chair; 26 members present.

The Secretary presented, for Mr. Morris P. Janney, a note upon the Differential Gauge as Used at Blast Furnaces.

At the instance, also, of Mr. Janney, attention was called to the recent discussion of the Effect of Saccharine Matter on Mortars.

Prof. L. M. Haupt noted the Increased Weight of Locomotive Engines, as Affecting the Strains on Railway Bridges.

Prof. Haupt also referred to two recent legislative matters of interest to engineers; the Wheeler bill for the examination of the earth's crust, and progress in the matter of rapid transit for Philadelphia.

February 19th, 1887.—Regular Meeting.—President T. M. Cleemann in the chair; 34 members and 1 visitor present.

Mr. John Fernie, C. E., Member Institution of Civil Engineers, Institution of Mechanical Engineers, etc., of England, delivered a most entertaining and instructive address upon "The Mechanical Genius and Works of the Late Sir Joseph Whitworth."

March 5th, 1887.—Regular Meeting.—President T. M. Cleemann in the chair; 15 members and 1 visitor present.

Mr. S. L. Kneass presented an illustrated description of a new

Fixed Nozzle Automatic Injector that will restart itself, if from any cause its supply of water or steam be temporarily interrupted. It is especially designed for locomotive service, where its power of adapting itself to varying steam pressures, and its automatic action, are especially desirable.

He closed with a few remarks upon the theory of the action of the injector, and its efficiency.

Mr. R. W. Lesley presented illustrated notes upon the Manufacture of Cement in the United States and the Growing Demand for High Class Mortars.

The Secretary presented, for Mr. Theo. J. Lewis, a paper upon 3 ins. vs. 4 ins. Thick Steel Tyres.

The Secretary presented, for Mr. A. P. Broomell, an illustrated description of the Large Engines being built to drive the Centrifugal Pumps for reclaiming the Potomac Flats, Washington, D. C.

The Secretary also presented, for Mr. Broomell, a copy of an Ice Machine, which he had designed with a view of overcoming some of the objectionable features in previous machines.

March 19th, 1887.—Regular Meeting.—President T. M. Cleemann in the chair; 32 members and 3 visitors present.

The Secretary presented, for Mr. Wilfred Lewis, a note upon Phosphor-Bronze Wire for Helical Springs.

Mr. John L. Gill, Jr., presented a note on Screw Threads.

Mr. H. H. Sintzenich, introduced by Mr. Henry G. Morris, exhibited and described a Rail Chair.

The Secretary presented, for Mr. F. H. Lewis, a paper upon the Clapp-Griffiths Steel for Structural Work.

Mr. Percival Roberts, Jr., followed with some discussion of the paper, questioning that any advance in steel manufacture could be claimed for this process.

The Secretary presented, for Mr. Emile Low, a paper upon Maps for Railroad Surveys.

April 2d, 1887.—Business Meeting.—President T. M. Cleemann in the chair; 32 members and 5 visitors present.

The Tellers of Election, Prof. Arthur Beardsley and Mr. Thos.

H. Graham, reported that 91 votes had been cast, and that the following were elected Active Members of the Club: Messrs. Conway H. Day, Lino F. Rondinella, Henry S. Prichard, Eugene A. Rhoads, A. Wells Robinson, George N. Bell, Joseph Powell, Jr., and Griffith W. Jones.

The Secretary presented, for Mr. Theo. Low, Notes on Railroad Construction.

Mr. F. W. Whiting, introduced by Mr. L. C. Madeira, Jr., presented a paper upon the Prevention of the Spreading of Fires, treating especially of the relation of the proper and scientific design and construction of buildings to their safety from entire destruction in case of the starting of a fire within them.

Mr. Francis Lightfoot, introduced by Mr. J. Kay Little, exhibited and described a Stamp Splice, Tongue and Groove Rail Joint.

Mr. Max Livingston presented a paper on Petroleum.

The Secretary presented a communication from Mr. Gratz Mordecai, suggesting an active interest on the part of the Club in local engineering matters and public work. It was referred to the Board of Directors.

The resignations from Active Membership of Captain J. C. Mallery and Mr. P. A. Taylor were read and accepted.

April 16th, 1887.—Regular Meeting.—President T. M. Cleemann in the chair; 24 members present.

The Secretary presented, for Mr. Edwin Ludlow, Notes on the Preparation of Anthracite Coal.

Mr. J. E. Codman presented a description of a Perpetual Motion Machine, which had been offered by a western correspondent of the Philadelphia Water Department, as a means of supplying Philadelphia with water at an annual running expense of five dollars.

May 7th, 1887.—Regular Meeting.—President T. M. Cleemann in the chair; 19 members present.

The Secretary presented an illustrated paper by Mr. Lewis N. Lukens upon Some Remarkable Breaks in a Reservoir.

Capt. S. C. McCorkle exhibited a map of the Rivers in the

vicinity of New York, made for commercial purposes, and referred to the proposed preparation of a similar map of the Rivers in the vicinity of Philadelphia, requesting the discussion of the subject by the Club.

It was suggested that the Schuylkill River above Fairmount Dam be included in the survey and plan, as a great convenience to some 1,500 members of the Philadelphia rowing fraternity, but Capt. McCorkle stated that the government work could not be extended above tide water.

It was also suggested that it would make the map more generally useful if the streets and other topography were extended across the city or farther inland, instead of, as in the New York map, only showing the wharves, piers and other water front lines.

The discussion was adjourned and its further continuance invited.

May 21st, 1887.—Regular Meeting.—President T. M. Cleemann in the chair; 33 members and 4 visitors present.

There was some further discussion of the form and arrangement of the proposed U. S. C. and G. Survey Map of the Delaware and Schuylkill Rivers near Philadelphia. The consideration of a resolution expressing the views of the Club was deferred till the next business meeting.

The Secretary presented two communications from Capt. S. C. McCorkle, embodying data on the Retardation of the Tide in the Vicinity of Philadelphia, etc.

The Secretary presented, for Mr. W. L. Hoyt, a Multiplication Table, from 1 to 25, for the Reference Book.

Mr. John L. Gill, Jr., presented an illustrated discussion as to Whether the Custom of Upsetting the Ends of Bridge Rods should be Abandoned.

Mr. Arthur Marichal read an illustrated paper on the Construction of Reservoir Walls.

Some discussion followed by Messrs. J. E. Codman, Frederic Graff and Howard Murphy.

Mr. J. E. Codman presented a Diagram for the Regulation of Dimensions, etc., of Cast-Iron Flange Pipes.

Mr. Edward Hurst Brown described a test he had witnessed of Fire-Resisting Paint.

Mr. R. Meade Bache exhibited a Safety Self-Extinguishing Car Stove.

June 4th, 1887.—Regular Meeting.—President T. M. Cleemann in the chair; 18 members and 1 visitor present.

Owing to the unexpected absence of the author, the paper of the evening had to be deferred.

The evening was, however, profitably spent in a general discussion of the proportions and strengths of certain structures which can hardly be calculated with mathematical precision, such as floors built up of separate layers of boards, ribbed and perforated cast-iron chamber and manhole covers, balloon frame buildings, etc. Some interesting illustrations were presented.

June 18th, 1887.—Business Meeting.—President T. M. Cleemann in the chair; 11 members present.

The Tellers of Election, Messrs. J. E. Codman and Arthur Marichal, reported that 112 votes had been cast, and that the following were elected. *Active Members:* Messrs. W. H. Frances, P. Doyle, John C. des Granges and Francis W. Whiting. *Associate Members:* Messrs. Robert Neilson and Horace B. Powell.

The resignation from Active Membership of Mr. S. N. Stewart was read and accepted.

The Secretary offered the following resolution, which was unanimously adopted:

Whereas, The Club has examined United States Coast and Geodetic Survey Chart, No. 369^4, of the Hudson and East Rivers in the vicinity of New York, scale $\frac{1}{10000}$, with a view of considering the value of a proposed similar chart of the Delaware and Schuylkill Rivers, near Philadelphia;

Resolved, That the Club is highly pleased with this form, arrangement and scale, and have no amendments or changes to suggest, and believe that such a chart of the Philadelphia rivers would be of great value to the profession and the public.

Mr. John L. Gill, Jr., presented a description of a New System of Screw Threads which he had arranged, and asked that a Committee be appointed to examine and report upon the same. The President appointed the following Committee: Messrs.

Henry G. Morris, *Chairman*, John T. Boyd, Prof. L. M. Haupt, Washington Jones and M. R. Mucklé, Jr.

The Secretary presented, for Mr. E. L. Corthell, an illustrated account of A Venetian Ship Railway.

The Secretary presented, for Mr. C. H. Middleton, Jr., an interesting letter descriptive of Camp Life on the Union Pacific Railway Surveys.

Mr. S. P. Mitchell presented an illustrated description of the Susquehanna River Bridge of the B. & O. R. R.

The Secretary presented, for Mr. R. Meade Bache, an illustrated description of a Boat Telemeter.

On motion, the Club adjourned till the first Saturday in October.

October 1st, 1887.—Regular Meeting.—Past-President Washington Jones in the chair; 30 members and 4 visitors present.

Mr. J. M. Cameron, introduced by Mr. Henry G. Morris, described the Carnell Air Injector.

Mr. Henry G. Morris exhibited and described a working model of a Traveler to Carry Wires, Ropes, etc., through Conduits.

Prof. L. M. Haupt made some remarks upon his experiments with Current Deflectors at Five-Mile Bar.

The Secretary announced the death, since our summer adjournment, of Mr. Frank Maddock, Active Member of the Club.

October 15th, 1887.—Regular Meeting.—Past-President Frederic Graff in the chair; 20 members and 1 visitor present.

Mr. A. Marichal presented a description of the Gileppe Dam, Belgium, illustrated by photograph and drawings.

Mr. A. Saunders Morris presented notes upon Connections for Secondary Batteries.

Arrangements for connecting the elements of storage batteries have given some trouble, principally on account of oxidation. The best form of connection is one in which the joint is removed as far as possible from the acid, and which can be readily detached for the purpose of removing the element.

Several forms of binding posts or connections were exhibited, made of tough lead alloy. Both male and female threads are

cast so that the castings are turned out of the moulds, completely finished, at the rate of one per minute. The mould for casting the screws was also exhibited.

The Secretary presented, for Mr. W. H. Nauman, a description of Tests for Riveted Joints, made at Watertown Arsenal, Massachusetts, for the Bureau of Steam Engineering, September, 1886, accompanied by very complete drawings and tables.

Mr. Henry Roeske, of Philadelphia, introduced by the Secretary, presented an illustrated description of a system of Water Filtration.

November 5th, 1887.—Business Meeting.—President T. M. Cleemann in the chair; 17 members present.

The Tellers of Election, Messrs. A. J. Fuller and A. Marichal, reported that 114 votes had been cast, and that the following were elected Active Members of the Club: Messrs. Henry I. Snell, Henry B. Seaman, Frank Cooper, Arthur H. Wood, Erwin Graves, I. H. Wainwright and Fred. J. Amweg.

The Secretary called attention to the fact that the 17th of December of this year would be the tenth anniversary of the organization of the Club, and recommended that it be observed by the holding of a reception in the Club House on that evening. After some discussion the following resolution, offered by Mr. John T. Boyd, was unanimously adopted:

Resolved, That a Committee, with power to act, be appointed to take charge of a Decennial Anniversary Reception, to be held in Club House on December 17th, 1887, at 8 o'clock P.M.; said Committee to consist of as many members as Chair may decide, who shall issue cards of invitation, given on request of members, the latter to be entitled to invite not exceeding three members of the engineering or architectural professions, all members being requested to subscribe two dollars by notice sent by the Secretary; and that such other invitations may be issued as the Committee shall deem proper and desirable.

Mr. Boyd declined, on account of pressure of business, to serve on the Committee, which the President appointed as follows: Messrs. Percival Roberts, Jr., *Chairman*, E. V. d'Invilliers, Prof. L. M. Haupt, C. G. Darrach and Frederic Graff.

Mr. C. G. Darrach presented a paper upon Boiler Specifications, which was discussed at length by Messrs. John T. Boyd, Chas. T. Thompson, A. Marichal, J. E. Codman and others. At a late hour Mr. Codman moved that the discussion be continued, and that such copies of the specifications as the author could supply be sent to such members as would probably take part in the discussion, which was adopted.

November 19th, 1887.—Regular Meeting.—President T. M. Cleemann in the chair; 35 members and 1 visitor present.

The Secretary presented, for Mr. W. H. Nauman, a paper upon the Calorimetric Investigation of the Performance of a Compound Engine, embodying considerable tabular data.

Mr. J. E. Codman presented a description, illustrated by specimens, etc., of Cement Tests, showing the effect the shapes of specimens had upon the results.

There was some discussion by Mr. A. Marichal.

The Secretary presented, for Mr. C. H. Haswell, a specimen of Cement.

The discussion of Mr. C. G. Darrach's paper upon Boiler Specifications was continued by Messrs. J. T. Boyd, O. C. Wolf, P. Roberts, Jr., A. Marichal and the Secretary. The Secretary presented a communication thereon from Mr. G. R. Henderson.

December 3d, 1887.—Business Meeting.—President T. M. Cleemann in the chair; 38 members and 1 visitor present.

Officers to serve during 1888 were nominated.

Mr. Percy T. Osborne presented an illustrated paper on the Palmetto Railroad, the connecting link in a new through line to the South.

Mr. R. B. Osborne presented an illustrated paper upon the Unaccountable Deficiency in the Track of American Railways.

Considerable informal discussion followed.

The Secretary presented to the Library, on behalf of Messrs. R. B. & P. T. Osborne, Active Members of the Club, a handsome copy of Williams' copper plate mounted Map of the United States, Canada, Mexico, Central America, West Indies, etc., which was received with a vote of thanks.

December 17th, 1887.—Decennial Reception.—Both members and guests seem to have been much pleased with this little entertainment. It is almost impossible to exactly determine the number present, but it looks very much like three hundred and forty-two. We were not, however, overcrowded, and, judging from the fragments that remained, everybody had enough to eat, —— and smoke. There was no speech-making or any attempt to introduce any feature which might have deprived the affair of an entirely informal and purely sociable character. It is believed that this entertainment will be of substantial and permanent benefit to the Club.

January 14th, 1888.—Tenth Annual Meeting.—President Thomas M. Cleemann in the chair; 44 members and 1 visitor present.

The Retiring President, Mr. Thomas M. Cleemann, delivered the Annual Address.

The Tellers of Election, Messrs. John L. Gill, Jr., and John S. Mucklé, reported that 167 votes had been cast, and that the following had been elected members of the Club. *Active:* Messrs. Louis H. Parke, Barton H. Coffey, Agnew T. Dice, Simon C. Long, Jacques W. Redway, Samuel Bell, Jr., Geo. W. Chance, Charles H. Haupt, George W. Creighton, Jawood Lukens, Alan Wood, Jr., Chas. R. Hall, Robert A. Cummings, T. W. Simpson, Gen'l W. F. Smith, Charles Lukens, Herbert Bamber and Barnabas H. Bartol. *Associate:* Messrs. George T. Mills, Michael Clarkson and A. J. Rudderow; and that the following had been elected:

Officers for 1888.

President—Joseph M. Wilson.

Vice-President—John T. Boyd.

Secretary and Treasurer—Howard Murphy.

Directors—T. M. Cleemann, Frederic Graff, Prof. L. M. Haupt, Washington Jones and Henry G. Morris.

President-elect Joseph M. Wilson, in taking the chair, made an appropriate address.

The Secretary and Treasurer presented his Annual Report for the fiscal year 1887.

On motion of the Secretary and Treasurer, his accounts for 1887 were referred to the Finance Committee of the incoming Board of Directors for audit.

The following resignations, which had accumulated during the year, were accepted. From *Active Membership:* Messrs. Kenneth Allen, Dana C. Barber, T. Benton Brown, R. W. Davenport, J. S. Elliott, Oliver B. Harden, Chas. S. Heller, W. H. Jones, H. K. Nichols, W. A. Parry, W. J. Root and Alexander Wurts; and from *Associate Membership:* Messrs. E. V. Douglas, J. H. Schwake and E. Y. Townsend.

The Secretary presented a communication from Mr. M. R. Mucklé, Jr., Secretary of the Local Committee for the Philadelphia Meeting of the American Society of Mechanical Engineers, thanking the Club for having placed its house at the disposal of that Committee.

The Secretary presented a communication from Mr. Walter Wood, Chairman of the Finance Committee of the Local Entertainment Committee of the American Society of Mechanical Engineers, transmitting to the Club $206.35, a portion of the unexpended balance in the hands of that Committee, which the subscribers desired to present to the Club. The Secretary recommended that this sum be placed in the permanent furnishing fund, and that a portion thereof be appropriated for the erection of book shelves in the first-floor back room.

The contribution was received with a special vote of thanks, and the recommendation of the Secretary adopted.

Mr. A. Marichal read a paper on the Plan Formation of Quaker Bridge Dam.

There was some discussion by Mr. J. E. Codman, who defended the plan of the dam.

Mr. H. S. Prichard presented an illustrated description of a Graphical Method of Determining the Deflection of Bridges.

An open draw-bridge is chosen for illustration.

The usual formula for calculating the variations in the length of each member, due to the strain, is given. Then, by means of diagrams, a graphic method of obtaining the deflections from these variations in length is explained, its application to the draw-bridge shown, and suggestions given for its use in other forms of bridges.

January 21st, 1888.—Regular Meeting.—President Joseph M. Wilson in the chair; 24 members and 1 visitor present.

The Secretary presented, for Mr. C. H. Ott, an account of a Peculiar Case of Transmission of Vibrations and Pulsations through Structures.

Mr. Joseph M. Wilson referred to the evil effects of continuous vibrations in structures, and noted, incidentally, a case in his recent practice where large marble blocks had been broken by the freezing of water in the lewis holes; Mr. Howard Murphy referred to the vibration in the large Scotch stacks, and Mr. Henry G. Morris noted the case of a stack 125 ft. high, where the vibration was $1\frac{1}{2}$ ins. Messrs. Seaman, Haupt, Cleemann, Brown and Redway took part in the discussion.

Prof. L. M. Haupt submitted a few extracts from the Report of the Chief of Engineers with reference to the Theoretical Operation of Submerged Jetties, and made some comments thereon.

Mr. A. Marichal presented a mathematical discussion of the Theory of Curved Dams, for the Reference Book.

Mr. F. W. Whiting noted a case in hydraulics, where attempt had been made to bring water in a pipe across an embankment, which had been unsuccessful until an opening was made at a point in the pipe line, and a small pipe extended therefrom to the level of the source.

Mr. Howard Murphy suggested that the trouble had probably been caused because the hydraulic gradient had not been considered in the original location of the main pipe.

February 4th, 1888.—Business Meeting.—Past-President L. M. Haupt in the chair; 19 members present.

Prof. L. M. Haupt, of the Committee representing the Club, submitted, with comments and explanations, and other data, House Bill No. 4923, "To regulate certain expenditures in the War Department and for other purposes"—relative to the establishment of a Bureau of Harbors and Waterways, to be officered by a corps to be known as the Corps of U. S. Civil Engineers.

The Secretary presented, for Mr. Rudolph Hering, the following preamble and resolution which had been passed by the

American Society of Civil Engineers, which, after some discussion, with the substitution of the name of the Club, were adopted:

WHEREAS, It is deemed highly desirable by the Engineering profession that better information should be collected than is now available regarding the intensity of rainfalls in different sections of the United States, particularly with reference to the practical questions involved in the construction of works for water supply and sewerage, and

WHEREAS, It is entirely feasible for the Signal Service Bureau to obtain such information without increase of force, but simply by the erection of automatic, self-registering rain gauges in addition to those now employed; therefore

Be it Resolved, That the Engineers' Club of Philadelphia respectfully urges upon Congress the desirability of inserting in the next annual appropriation bill for the Signal Service Bureau an item sufficient to cover the expense of placing automatic rain gauges at all principal stations, as the Chief Signal Officer may direct.

Mr. A. Marichal read a paper on Rainfall.

A series of resolutions relative to the publication of papers were presented by Mr. J. E. Codman and others; a letter offering amendment to the same was presented from Mr. Charles G. Darrach; there was a lengthy discussion and many suggestions were offered. The Secretary pointed out some of the practical difficulties in the way of accomplishing the most desirable results, and moved that the whole subject be referred to the Publication Committee that it might be formulated and discussion invited, which was so ordered.

Mr. A. Ely and others offered a resolution to the effect that the Club approve and adopt the 24-hour system of time notation. On motion, consideration thereof was postponed until the next business meeting.

The resignations from Active Membership of Messrs. Samuel Jamison, Henry W. Loss and Robert Wetherilll were accepted.

On motion of Mr. H. C. Lüders it was ordered that hereafter no new paper shall be presented at Regular Meetings after 10 o'clock P.M., unless ordered by vote of the meeting.

Of the Board of Directors.

Continued from Vol. V, No. 4, page 364.

December 18th, 1886.—President Washington Jones in the chair.

Messrs. John S. Mucklé and Wilfred Lewis were appointed Tellers, and Chas. T. Thompson and Strickland L. Kneass, Alternates, to conduct the next Annual Election.

A request was presented, from Dr. Harrison Allen, that the American Society of Naturalists be accorded the privilege of the use of our rooms for their coming meeting (December 28th, 29th and 30th, 1886). The request was granted.

Permission was given to Mr. Frederic Graff to allow a friend of his to take a photograph of the view of the Wernwag Bridge in possession of the Club.

January 22d, 1887.—President T. M. Cleemann in the chair.

The President announced the following Standing Committees for 1887:

Finance—Messrs. Frederic Graff and Washington Jones.

Membership—Messrs. M. R. Mucklé, Jr., and John T. Boyd.

Publication—Messrs. C. W. Buchholz and Jos. M. Wilson.

Library—Messrs. Washington Jones and M. R. Mucklé, Jr.

House—Messrs. John T. Boyd and C. W. Buchholz.

The Secretary reported that he had been successful in recovering at law an amount due the Club.

At the suggestion of the Secretary, President Cleemann was requested to sit for his phototype portrait for insertion in our Proceedings.

February 19th, 1887.—President T. M. Cleemann in the chair.

The Secretary informed the Board that the Corresponding Members on the roll had failed to comply with Art. VI, Sect. 5 of the By-Laws, and recommended that they be accordingly dropped from the roll, which recommendation was unanimously adopted.

March 19th, 1887.—President T. M. Cleemann in the chair.

Routine Business.

April 2d, 1887.—President T. M. Cleemann in the chair.

The Secretary stated that our circulation of the Proceedings, in other channels, had so increased as to compel us to limit the number of author's free copies. It was ordered that the number of free copies hereafter given to authors should be governed by circumstances, according to the discretion of the Secretary.

April 16th, 1887.—President T. M. Cleemann in the chair.

The Secretary presented a communication from Mr. Gratz Mordecai, Active Member of the Club, which had been referred to the Board by Business Meeting of April 2d, 1887. The object of the communication was to urge an active participation of the Club in matters of local and general public engineering work, by the establishment of Committees to examine, report upon and foster public discussion of such matters.

After some discussion it was advised by unanimous vote, that Mr. Mordecai be informed that the views of the Board are that members could not be induced to give the time required for so great a work, and could not be expected to give professional opinions and furnish professional information without proper compensation.

May 21st, 1887.—President T. M. Cleemann in the chair.

The Secretary presented a further communication from Mr. Gratz Mordecai to the President, relating to the active participation of the Club in matters relating to public engineering work. It was, on motion, laid on the table.

The Secretary presented a communication from Prof. L. M. Haupt, stating that he had resigned from the Executive Board of the Council of Engineering Societies on National Public Works, and asking that the Club be represented by some other member. He also referred to the question of an appropriation by the Club, to meet their share of the expenses of the Board. The opinion seemed to prevail that a new member could hardly take up at this time the unfinished work of Prof. Haupt, and, on motion, the communication was laid on the table.

The Secretary recommended the placing of insurance upon the personal property of the Club, and was authorized to do so to the

extent of a valuation of $3,000, until the expiration of our present lease.

June 4th, 1887.—President T. M. Cleemann in the chair.

The Secretary stated that, in placing the insurance upon our personal property, he had found that he could secure more favorable terms by taking a five years' policy, rather than a policy to the expiration of our present lease, and that said five-year policy could be transferred in the event of our removal, and he had, therefore, taken out the five-year policy. His action was approved by the Board.

Mr. Boyd suggested some form of notice to members as to the removal of property from the Club House. After some discussion the Secretary recommended the printing in suitable type and posting of Article XI of the By-Laws, relating to this subject, which recommendation was adopted.

Prof. L. M. Haupt, by invitation, presented an account of the work of the Executive Board of the Council of Engineering Societies on National Public Works, and of the situation of that Board with reference to expenses. No pro rata assessment had been made on the Clubs represented therein. Prof. Haupt had forwarded the data he had accumulated to that Board, with his resignation, which he desired also to present to this Club, on account of his recent sad bereavements.

The resignation of Prof. Haupt was accepted with regret, and the Secretary directed to request Mr. E. L. Corthell to act in his place, with Mr. Rudolph Hering as alternate, the two latter gentlemen being the remainder of the Committee representing this Club.

As to the expenses, the Secretary recommended that $100 be contributed by this Club voluntarily, to be taken, at present, from Club funds, and, should it be found necessary, replaced by private subscription at close of year, which recommendation was adopted.

June 18th, 1887.—President T. M. Cleemann in the chair.

Routine business.

Note.—Between meetings the Board approved, by letter, of

extending the use of our rooms to the Local Committee of the American Society of Mechanical Engineers.

JANUARY 14TH, 1888.—President T. M. Cleemann in the chair.

The vouchers for the fiscal year, 1887, Nos. 1 to 52, both inclusive, all of which had been approved by the Finance Committee, were presented by the Secretary and Treasurer, and were approved by the Board.

The Board of Directors for 1887 then adjourned *sine die.*

JANUARY 21ST, 1888.—President Jos. M. Wilson in the chair.

The Secretary suggested that President Jos. M. Wilson be requested to sit for his phototype portrait for insertion in the Proceedings. Adopted.

The Secretary suggested the insertion in the Proceedings of a phototype portrait of the late Thomas U. Walter, Honorary Member of the Club. Adopted.

The Secretary suggested that the preparation of suitable text to accompany Mr. Walter's portrait be referred to the Publication Committee, with power to act. Adopted.

The Secretary reported that a balance of $116.$\frac{91}{100}$ on Furnishing Account would be available for the erection of shelving for the library. Referred to the Library Committee.

FEBRUARY 18TH, 1888.—Mr. Henry G. Morris in the chair.

Routine business.

BOOK NOTICES.

A METHOD OF CALCULATING THE CUBIC CONTENTS OF EXCAVATIONS AND EMBANKMENTS, BY THE AID OF DIAGRAMS. TOGETHER WITH DIRECTIONS FOR ESTIMATING THE COST OF EARTHWORK. By John C. Trautwine, Civil Engineer. Ninth Edition, revised and enlarged by John C. Trautwine, Jr., C. E. New York: John Wiley & Sons, 1887.

At last we have to record the appearance of a new edition of Trautwine's "Excavations and Embankments," the first since

1883. Its production has been delayed by the work of revision of "The Civil Engineer's Pocket-Book," of which we have received three editions during the same time.

"Excavations" has been thoroughly revised. The principal feature is, as heretofore, the author's graphic method of reducing sloping sections to equivalent level ones; and the tables and copper-plate diagrams given for this purpose occupy a considerable part of the volume.

The rules for estimating the cost of earthwork have been supplemented by remarks upon the cost, etc., of operation of the modern wheeled and drag scrapers and steam excavators, taken from late editions of "The Pocket-Book."

The book is very neatly bound. It contrasts strongly with earlier editions in this respect.

We note that Trautwine's Cross-section Diagram has also undergone improvement, and is now published by the Messrs. Wiley.

Trautwine's Civil Engineer's Pocket-Book. Twelfth edition, Twenty-eighth thousand, 1887. New York: John Wiley & Sons.

The principal changes in the last two editions of this work are, perhaps, the presentation of a proposed uniform loading in the determination of the stresses in members of trusses, a change proposed by Mr. G. H. Pegram within a year or so, and which has met with almost, if not quite, unanimous approval from bridge engineers, and a remodeling of the formula for finding approximately the weights of truss bridges. The formulæ for thicknesses of cylinders under internal pressure, and the table of foreign coins, have been entirely revised, and the table of the co-efficient "*c*," by Kutter's formula, has been greatly extended. We note a large number of minor changes, not the least important or least welcome being the substitution of the larger for the smaller type to the extent of about thirty pages.

GEOLOGICAL SURVEY
OF
PENNSYLVANIA,
907 Walnut St., Philad'a.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

NOTE.—The Club, as a body, is not responsible for the facts and opinions advanced in its publications.

Vol. VI.] JUNE, 1888. [No. 5.

XXX.

MAPS FOR RAILROAD SURVEYS.

By EMILE LOW, Active Member of the Club.

Read March 19th, 1887.

THE preliminary and location lines of a railroad survey are usually plotted on a continuous roll of drawing paper, the length of the latter depending on the scale used and the length of the line run.

I think the less frequently used method of plotting the lines on separate sheets possesses many advantages over the continuous roll one.

For this purpose I advise the use of sheets measuring 19 by 24 inches, this size being technically known as *royal*. As to the kind of paper best adapted for the purpose, I find that paper bearing the imprint "Weston's Linen Record" gives excellent results. This paper has a smooth finish and can be readily obtained of the size mentioned above.

For plotting I prefer the scale of 200 feet to one inch, and according to which each sheet will thus contain about one mile.

counting the long way of the sheet, so that the number of sheets will correspond very closely with the length of the survey expressed in miles, excepting cases where the surveyed line is very crooked and devious.

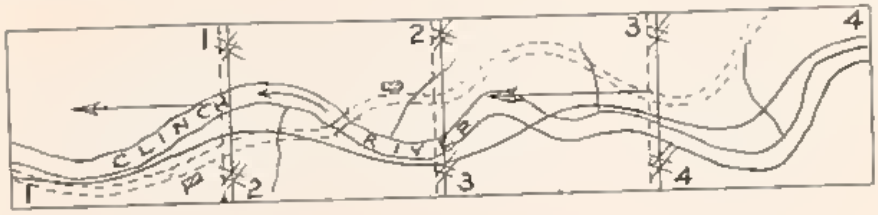
In plotting the line it is not necessary to place on the drawing table the whole number of sheets required; three or four will be a sufficient number at a time. They should be placed in a row, the top and bottom of the sheets being even, and at the same time letting the edges overlap one-half inch. After the sheets are placed down and securely fastened with thumb tacks, connect them at their overlapping edges by means of crosses drawn with red ink; this for the purpose of noting any change in their position while working on them, and also that the sheets may be accurately fitted together again after they have been taken up.

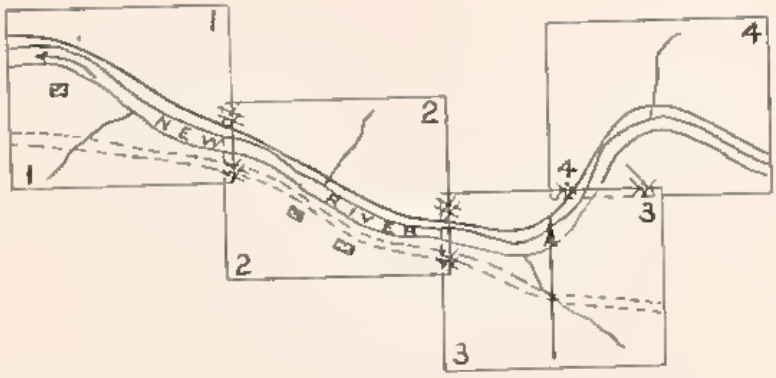
In order to properly identify the different sheets, mark them with appropriate numbers placed in the upper right hand and also in the lower left hand corner.

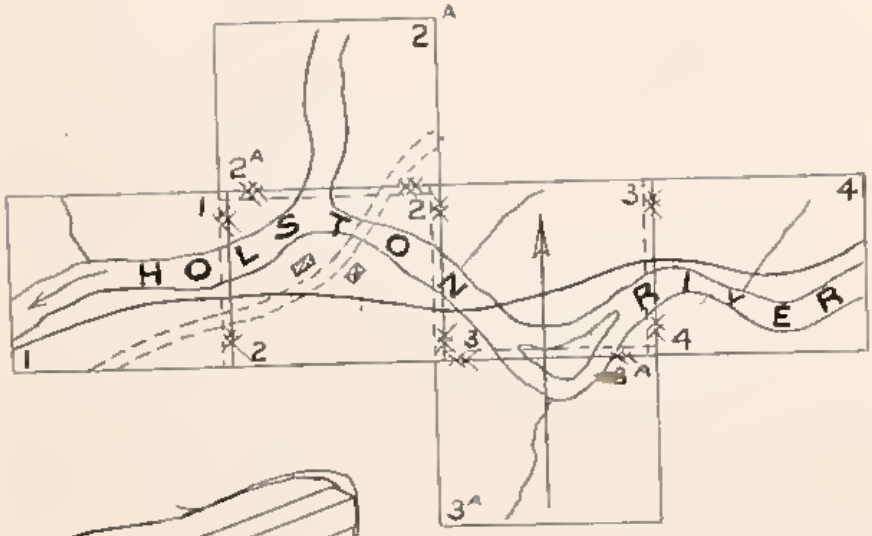
Make the meridian (north and south line) parallel with one of the edges of the paper, depending on the direction of the survey. When the line of the survey is either east or west, the meridian should be placed parallel with either the right or left hand edge of the paper; but when the direction is north or south, then the meridian should be placed parallel with the top or bottom of the sheets. The two middle figures of the inset show the first case, and the upper figure the second.

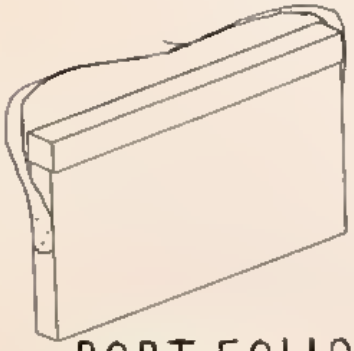
When the direction of the survey is not with the cardinal points it is apparent (with the meridian placed parallel to the edges of the sheets) that the plotted line will cross the sheets diagonally, and if they are placed together in a straight line, it is obvious that the line will run off the paper entirely. One way to obviate this is to step the sheets at their junctures either up or down, as the exigency may require, instead of placing them side by side in a straight line.

It is not to be advised though that a sheet be stepped up or down more than one half its width, as there is danger from too small a lap that they may not be able to be placed together (subsequently after their taking up) again in their exact original position.









PORT FOLIO

DIAGRAM

SHOWING APPLICATION OF SHEETS

FOR

MAPS OF RAILROAD SURVEYS.

Another method would be to determine the general direction of the line, and then placing the sheets in a row, plot the line as best suited. When the variation from an axis of the line to the right or left exceeds the width of a sheet, it would, of course, be necessary to place additional sheets above or below to cover the deficiency.

By this method the meridian would not be parallel to the edge of the paper, and for this reason I prefer the other plan of placing the sheets, for from an examination of the sheets an idea is rapidly formed of the direction of the survey.

The principle involved is the same as the one by which large maps are drawn, and that is to have the north end always on top. Of course it is only possible to have the top of the sheets *north* only when the line runs east or west. When it runs north or south I would prefer to have the east at the top.

Another advantage of plotting on sheets over rolls of paper is that any particular portion of the line can be more readily examined, and tracings can also be more easily made of separate parts. They can also be filed away in drawers, remaining flat all the time, and need not be rolled, thus keeping their shape better.

When a continuous map is desired, one can be made by using tracing cloth, the rolling of which is not so objectionable as that of heavy drawing paper. These sheets are also very useful in the field when running in on the ground a projected or *paper* location. They are more readily handled than a roll map, especially in windy weather. For their proper transportation a portfolio made of wood is very convenient; its inside dimensions should be a little larger each way than that of the sheets. The wood, either white pine or poplar, should be perfectly seasoned, so as not to warp or crack in the sun.

The sides of the portfolio are made $\frac{1}{4}$ inch in thickness, while the strip around the ends and bottom are made of $\frac{5}{8}$ by 1 inch material. These pieces fitted together form an oblong box, having an inside width of one inch. A lid made of tin and two inches deep is used to cover the top. A strap is also attached to the sides for convenience of carrying. It will be seen that the box or portfolio answers admirably for a map board, and in it can

be carried a couple of triangles, a paper protractor, etc. If a pocket box of instruments is also carried along, these will be sufficient drawing paraphernalia, to be used in the field as the occasion may require, and this is of frequent occurrence in running in a paper location.

XXXI.

A GRAPHIC METHOD OF DETERMINING THE DEFLECTON OF BRIDGES.

By H. S. Prichard, Active Member of the Club.

Read January 14th, 1888.

The case chosen for illustration is that of an open draw or swing bridge, shown in Fig. 1.

The variations in the length of each of the members are calculated by the formula $d = \frac{P\,L}{E\,A}$.

Where P equals the total strain on the member,
L " its original length,
A " " area,
d " " elongation or compression,
and E " the coefficient of elasticity.

In Fig. 1 the variations in length are called d, $d1$, $d2$, etc., and are indicated on each member, elongations being marked *plus* and compressions *minus*.

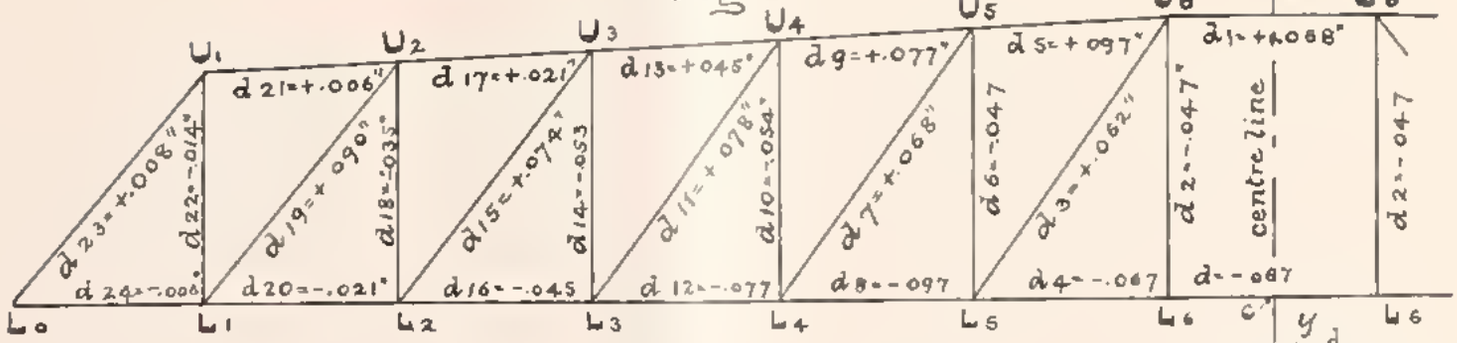
The general principles on which this method depends are as follows:

Let $A\ B\ D$, Fig. 2, be any one of the triangles into which the bridge can be divided, in its original position, before the bridge is strained.

Let A^1 and B^1 be the new positions of A and B when the bridge is strained, and $H\ G$ and $E\ F$ the variations in length of $A\ D$ and $B\ D$.

To find the new position of D: From A^1 draw a line parallel to $A\ D$ and lay off $A^1\ G$, equal to $A\ D$, and the variation $H\ G$.

Fig 1



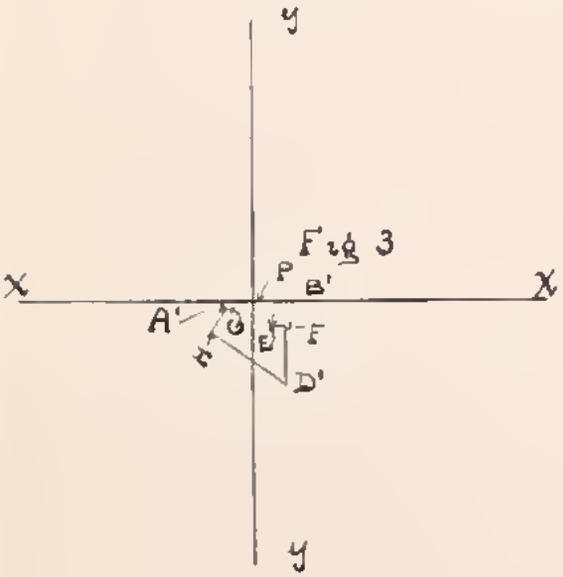


Fig 3

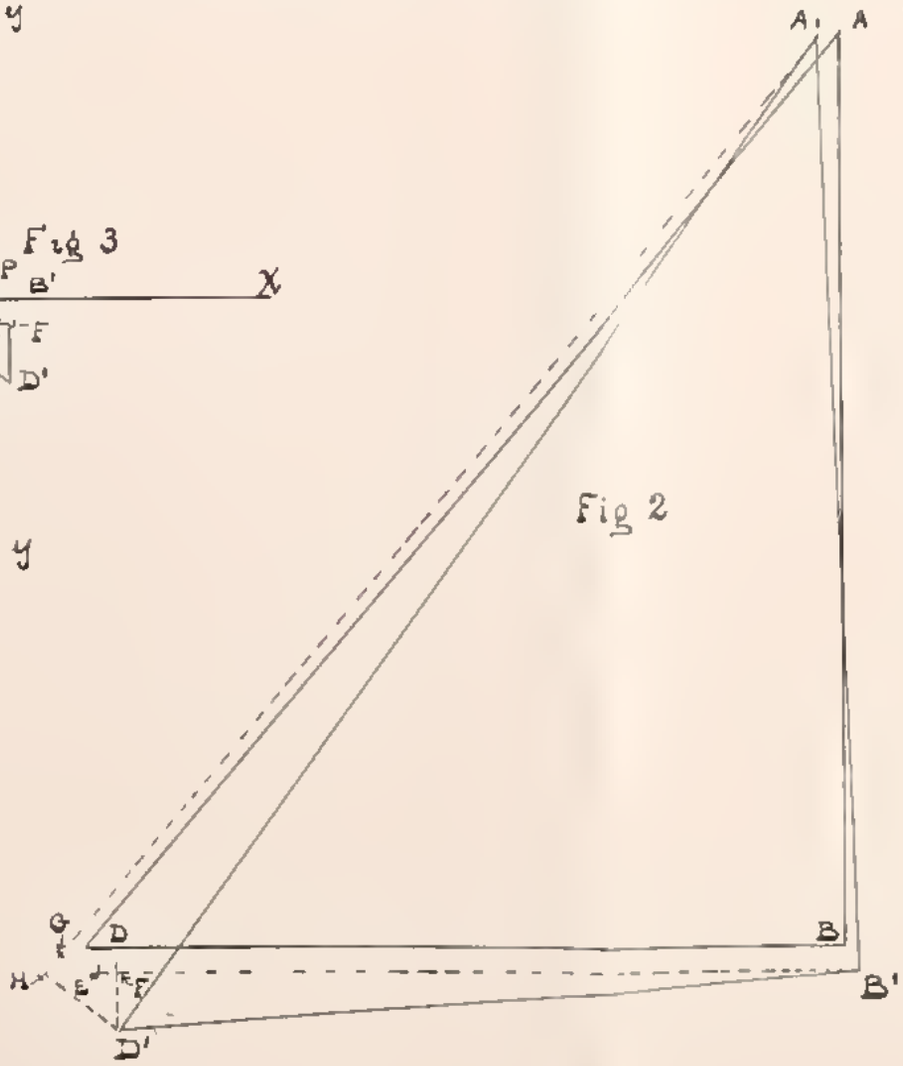


Fig 2

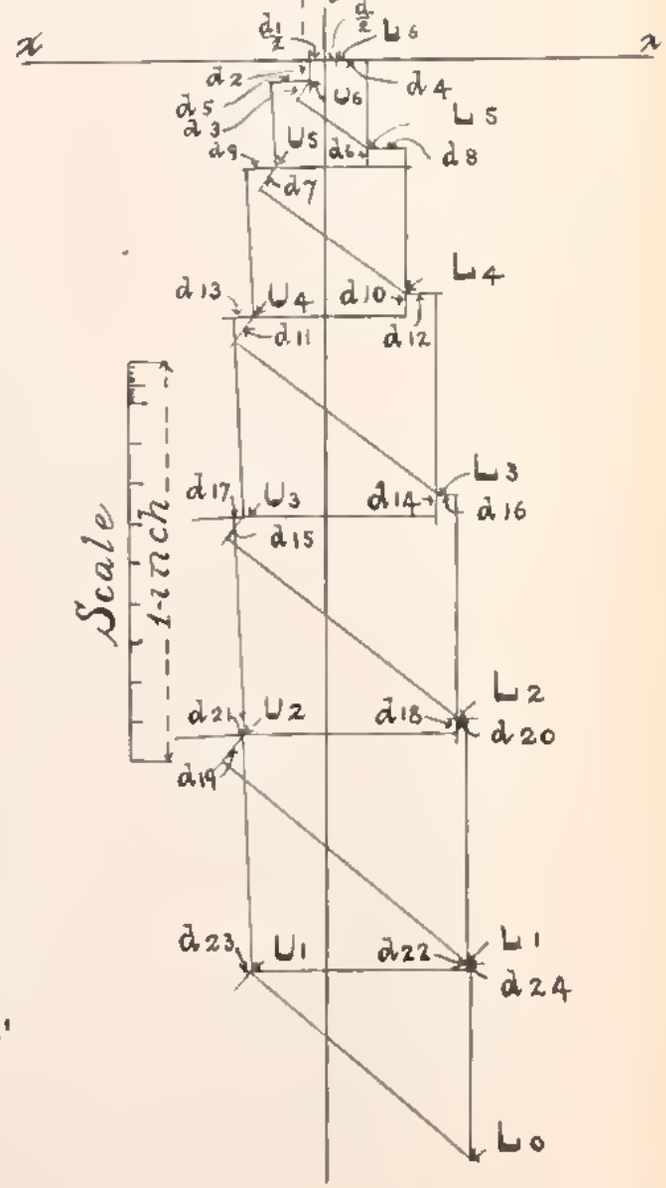


Fig 4

Also from B^1 draw a line parallel to $B\,D$ and lay off $E\,B^1 = D\,B$, and the variation $E\,F$. Then with A^1 and B^1, as centres, describe the arcs $H\,D^1$ and $F\,D,^1$ and their intersection D^1 will be the new position of D after the bridge is strained.

The arcs $H\,D^1$ and $F\,D^1$ are so small that perpendiculars to $H\,A^1$ and $E\,B^1$, erected at H and F, will intersect at practically the same point. As $A^1\,G$ is equal to and parallel to $A\,D$, G occupies the same position with regard to D as A^1 does to A.

In like manner, F occupies the same position with regard to D as B^1 does to B. It therefore follows that if the variations in position of A and B be plotted from a common point P, at the intersection of the vertical and horizontal axes y-y and x-x, Fig. 3, the variations in length plotted parallel to $A\,D$ and $B\,D$ from A^1 and B^1 and perpendiculars erected at H and F, their intersection D^1 will occupy the same position with regard to P as D^1 does to D.

To apply these principles draw a diagram of the truss, as shown in Fig. 1.

Then from the intersection of a vertical axis y-y, with a horizontal axis x-x, Fig. 4, as a point from which to measure variations, find in succession the variations in position of $L\,6$—$U6$—$L\,5$—$U5$ - - - - - $L\,0$, assuming point c at the centre of the bridge as constant.

The scale used for plotting the variations should be several times natural size to insure accuracy.

The deflection of an ordinary truss, simply supported on two abutments, can be found by considering the ends as lifted and the centre fixed.

This method can be applied to any form of truss, single or double intersection, and in the case of continuous girders the deflections would be a test of the accuracy of strains obtained from the formulæ in general use.

XXXII.

A PECULIAR CASE OF TRANSMISSION OF VIBRATIONS AND PULSATIONS THROUGH STRUCTURES.

By C. H. Ott, Active Member of the Club.

Read January 21*st*, 1888.

Late in the autumn of 1883 my attention was called to the rocking and swaying motion of the four-story building at the northwest corner of Eleventh and Chestnut Streets, in the Girard Row, the upper floors of which were then occupied by Our Continent Publishing Co. as editorial and composing rooms.

At certain hours of the day the motion was very perceptible, and was noticed in the rolling of water in vessels and swaying of gas fixtures, and could be plainly felt, so much, in fact, that several of the employees of the establishment were affected by a sensation similar to seasickness. On the rear of the building a chimney had become so loosened and shaken by the pulsations that it was necessary to have it torn down and rebuilt.

The matter became so serious as to threaten the stability of the structure, and active measures were taken to ascertain the cause and, if possible, prevent the pulsations.

It was ascertained that no motion or vibrations of a similar character and tending to affect the building in question were noticeable in any of the buildings in the remainder of the block fronting on Chestnut Street, between Eleventh and Twelfth Streets, the occupants of which were not even aware of any trouble.

The buildings in the "row" had all apparently been erected in a good, workmanlike manner, with suitable foundations; and unless there were unseen defects in the work, the theory first advanced, that the undulation was caused by the passage of heavy traffic in the adjacent streets, could not be entertained.

It was noted that the motion was only felt during certain hours of the day, viz.: between 8 A.M. and 6 P.M., and this led to the conclusion that it was caused by some heavy piece of machinery operated in some adjacent building, but investigation failed to find it.

After much inquiry and search it was discovered that in the

rear fourth floor of the building at the northeast corner of Chestnut and Twelfth Streets, then occupied as a grocery store, was a small steam engine used for the purpose of grinding spices and coffees.

No suspicion was at first attached to this piece of machinery as a cause of the trouble, from the fact of its being an engine for light duty, small in size, and its being nearly 400 feet distant from the building affected, and from the fact that its motion could barely be felt in the building in which it was located.

Experiments were instituted, by starting and stopping the engine at stated intervals, a proceeding which immediately proved it to be the cause of the trouble.

As a matter of convenience the engine was then supported by pillars from the cellar floor, but without causing the desired effect. Finally it was lowered to the cellar, a proceeding which gave entirely satisfactory results.

A general discussion of vibrations in structures followed, participated in by a large number of members, and numerous instances were noted. Mr. John T. Boyd described vibrations, in a large office building, that had never been satisfactorily accounted for; Mr. Henry G. Morris, in a large hotel, created by the elevator pumps; Mr. Howard Murphy, the relative effects of the earthquake on different floors of an office building; Mr. F. W. Whiting, where the fourth story of a five-story mill building, in Philadelphia, vibrates $\frac{3}{8}$ in., and a mill building, in Massachusetts, where the vibration is so great as to cause nausea among new employees, and where the water cannot be kept in a fire bucket, yet the building is probably at least ten years old and seems to stand it.

President Joseph M. Wilson referred to the evil effects of continuous vibrations in structures, and noted, incidentally, a case in his recent practice where large marble blocks had been broken by the freezing of water in the lewis holes; Mr. Howard Murphy referred to the vibration in the large Scotch stacks, and Mr. Henry G. Morris noted the case of a stack 125 feet high, where the vibration was $1\frac{1}{2}$ ins. Messrs. Seaman, Haupt, Cleemann, Brown and Redway took part in the discussion.

XXXIII.

THE RAINFALL.

By Arthur Marichal, Active Member of the Club.

Read February 4th, 1888.

It seems that very few people pay to the rainfall the attention it really deserves. They forget that it is the ultimate source of our water supply; that it is one of the most important factors in vegetation; that without it any vegetal or animal life would cease on the surface of the earth.

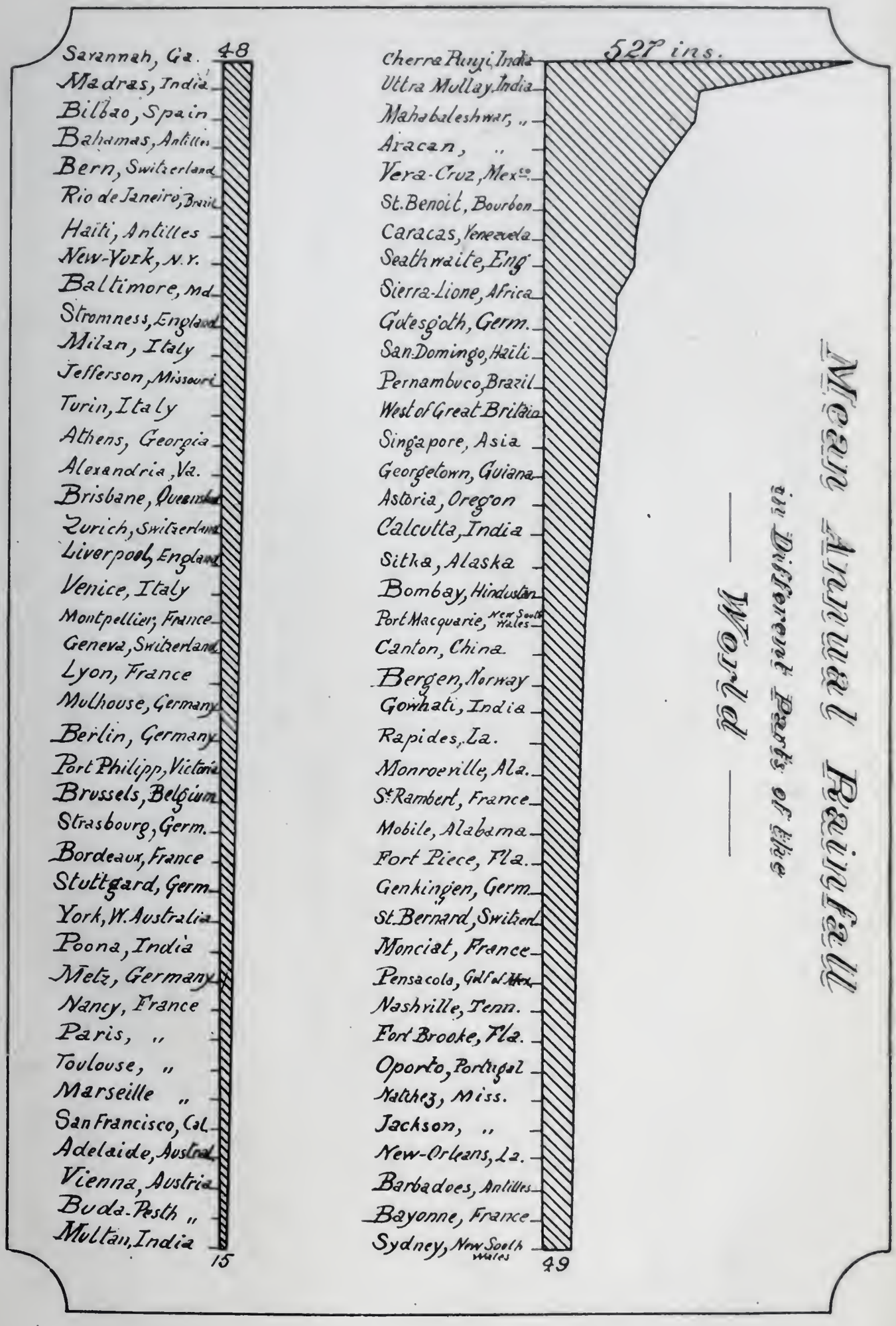
It must rain; a certain amount of rain is needed, and a scarcity as well as an excess may be the cause of the most appalling disasters. We do not need to go back to ancient history to find examples of such calamities. Recently an excess of rain has caused the loss of thousands of lives in the southern part of Asia.

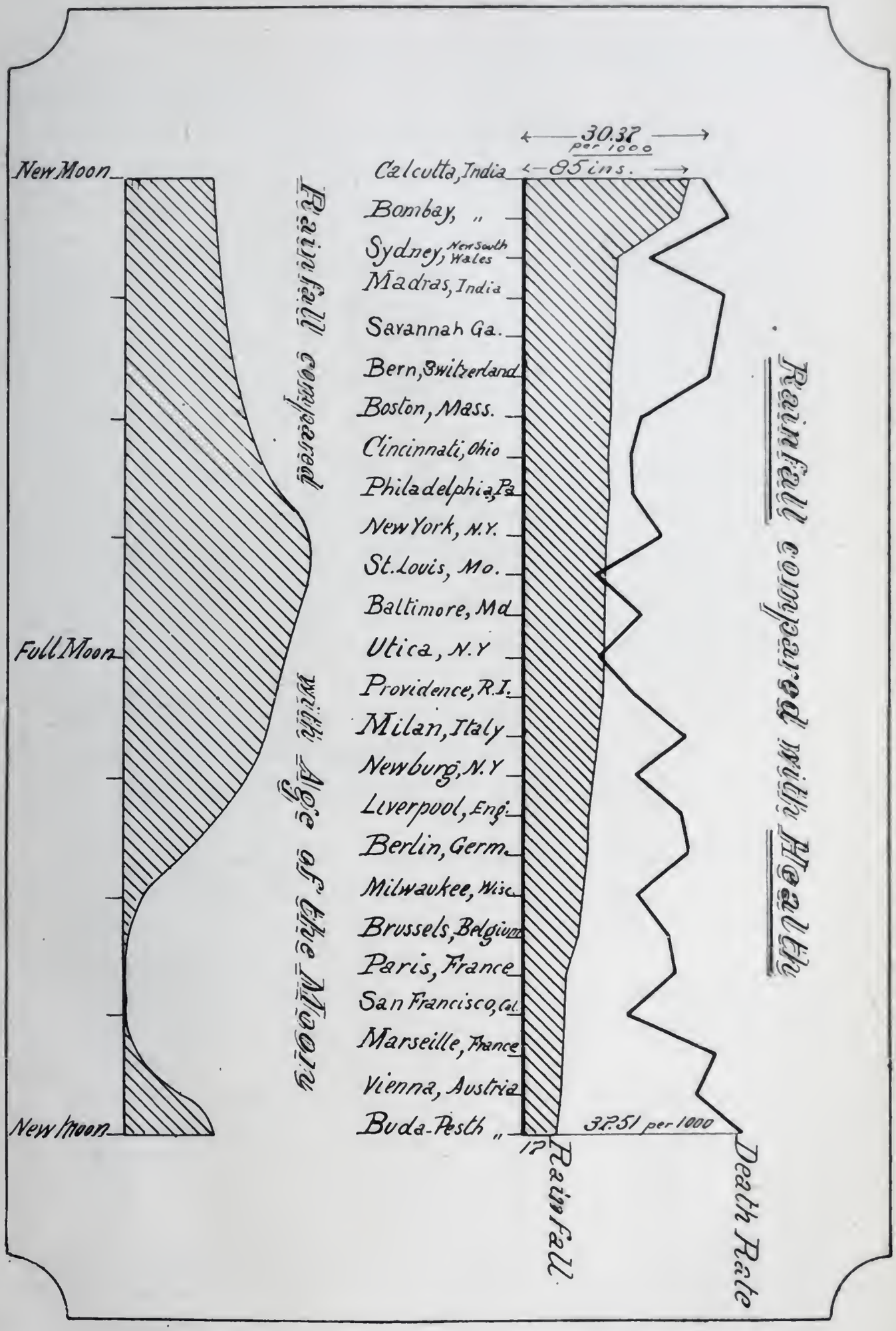
Who does not know of the terrible famine of 1060, when two provinces of Egypt were wholly depopulated. It was the result of a scarcity of water.

If it were possible to foretell these irregularities in the rainfall many disasters could be reduced in their consequences, if not entirely avoided. But no theory can give us a law to base our predictions; we are compelled to make continuous observations and from them deduce an empirical law, the accuracy of which will depend upon the number of our observations. It is not my intention to present to the Club a line of observations from which a law could be deduced. The time I can dispose of does not allow me such laborious statistics. What I want is to call the attention of parties having the opportunity to make such observations to the necessity of having detailed data on the rainfall.

The tables or diagrams which should be made are numerous; for instance: The rainfall all over the world; the rainfall per day, per month, per year, all over a given country, with height of barometer, temperature, prevailing wind, etc.

The rainfall compared with the stream-flow; the rainfall compared with the sanitary condition of a city or town.


Mean Annual Rainfall
in Different Parts of the
World
527 ins.
Savannah, Ga. 48
Madras, India
Bilbao, Spain
Bahamas, Antilles
Bern, Switzerland
Rio de Janeiro, Brazil
Haiti, Antilles
New-York, N.Y.
Baltimore, Md.
Stromness, England
Milan, Italy
Jefferson, Missouri
Turin, Italy
Athens, Georgia
Alexandria, Va.
Brisbane, Queensland
Zurich, Switzerland
Liverpool, England
Venice, Italy
Montpellier, France
Geneva, Switzerland
Lyon, France
Mulhouse, Germany
Berlin, Germany
Port Philipp, Victoria
Brussels, Belgium
Strasbourg, Germ.
Bordeaux, France
Stuttgard, Germ.
York, W. Australia
Poona, India
Metz, Germany
Nancy, France
Paris, "
Toulouse, "
Marseille "
San Francisco, Cal.
Adelaide, Austral.
Vienna, Austria
Buda-Pesth "
Multan, India
15
Cherra Punji, India
Uttra Mullay, India
Mahabaleshwar, "
Aracan, "
Vera-Cruz, Mex.
St. Benoit, Bourbon
Caracas, Venezuela
Seathwaite, Eng.
Sierra-Lione, Africa
Gotesgoth, Germ.
San Domingo, Haiti
Pernambuco, Brazil
West of Great Britain
Singapore, Asia
Georgetown, Guiana
Astoria, Oregon
Calcutta, India
Sitka, Alaska
Bombay, Hindustan
Port Macquarie, New South Wales
Canton, China
Bergen, Norway
Gowhati, India
Rapides, La.
Monroeville, Ala.
St. Rambert, France
Mobile, Alabama
Fort Piece, Fla.
Genkingen, Germ.
St. Bernard, Switzerl.
Monciat, France
Pensacola, Gulf of Mex.
Nashville, Tenn.
Fort Brooke, Fla.
Oporto, Portugal
Natchez, Miss.
Jackson, "
New-Orleans, La.
Barbadoes, Antilles
Bayonne, France
Sydney, New South Wales
49


Rainfall compared with Age of the Moon
New Moon
Full Moon
New Moon
Rainfall compared with Healthy
30.37 per 1000
85 ins.
Calcutta, India
Bombay, "
Sydney, New South Wales
Madras, India
Savannah Ga.
Bern, Switzerland
Boston, Mass.
Cincinnati, Ohio
Philadelphia, Pa
New York, N.Y.
St. Louis, Mo.
Baltimore, Md
Utica, N.Y
Providence, R.I.
Milan, Italy
Newburg, N.Y
Liverpool, Eng.
Berlin, Germ.
Milwaukee, Wis.
Brussels, Belgium
Paris, France
San Francisco, Cal.
Marseille, France
Vienna, Austria
Buda-Pesth "
32.51 per 1000
12
Rainfall
Death Rate

In the case of an epidemic, the rainfall compared with the progress of the disease.

The rainfall in relation with the age of the moon, etc.

I will give to the Club data, to show that laws can be deduced.

There is some part of the world where rain rarely or never occurs; the coast of Peru, the Sahara, in Africa, are rainless regions. In other parts the rainfall is enormous; 500 inches of rainfall is recorded in six months on the Khasia Hills, in India; at Joyeuse, in France, 31.17 inches fell in 22 hours; at Geneva, Switzerland, 30 inches in 24 hours; near Bombay, India, 24 inches fell in 10 hours; at New London, Connecticut, 5 inches fell in 4 hours.

One of the diagrams annexed to this paper gives the mean annual rainfall for 10 years in about 100 places of the world. Another diagram gives the mean annual rainfall compared with the mean annual death-rate of 10 years. It will be seen that, generally, too much rain is as bad as too little, and that the healthiest cities are those where the rainfall ranges between 35 to 45 inches.

The last diagram shows the rainfall in relation to the age of the moon (mean of 28 years in France).

The maximum rainfall occurs near full moon and the minimum near new moon.

I have compared this last experiment with a 20-year one made in Germany, and the same law was observed.

We should be very careful in drawing deductions. An example will better illustrate the facts.

It has been observed that a rain gauge was registering more rain when placed on the ground than it did when placed on top of a building:

At Paris	a difference	of level	of minus	73	feet	gives	13%	more	rain.
" Copenhagen	"	"	"	" 106	"	"	27%	"	
" Manchester	"	"	"	" 82	"	"	60%	"	
" York	"	"	"	" 175	"	"	72%	"	
" Pavie	"	"	"	" 46	"	"	1%	"	

From this we could deduce that less rain is falling on high ground than on low. Moreover, this theory would be verified in taking records of rainfall in the valleys of the leading streams of our country:

HUDSON RIVER.

New York	44 inches	Hudson	35 inches
Poughkeepsie	40 "	Albany	36 "

SUSQUEHANNA RIVER.

Havre de Grace	44 inches	Williamsport	39 inches
Harrisburg	49 "	Oswego	34 "
Lewisburg	39 "	Elmira	26 "

MISSISSIPPI RIVER.

Delta	60 inches	Memphis	42 inches
New Orleans	60 "	Cairo	42 "
Baton Rouge	60 "	St. Louis	42 "
Junction of Red River	56 "	Dubuque	38 "
Vicksburg	55 "		

But the leading streams of Europe would show just the reverse, as will be seen from the following tables:

VALLEY OF THE DANUBE.

Buda	17 inches	Ulm	27 inches
Vienna	19 "	Genkingen	62 "
Ratisbonne	23 "		

VALLEY OF THE PO (ITALY).

Venice	33 inches	Milan	39 inches
Padoua	34 "	Turin	39 "

VALLEY OF THE RHINE.

Middleburg	26 inches	Zurich	35 inch e
Haguenau	27 "	Berne	46 "
Strasbourg	28 "		

Concluding, I will say that we should not be too hasty in making deductions. The rainfall is one of the most capricious of phenomena. Unless our observations are detailed, complete and very numerous, it is impossible to deduce a law which would be of practical value.

XXXIV.

THE MANUFACTURE OF SEWER PIPE BY THE DELAWARE TERRA COTTA COMPANY.

By FREDERIC H. ROBINSON, Active Member of the Club.

Read February 18th, 1888.

THE works are situated on Brandywine Creek, between Heald and Eleventh Streets, and close to the Philadelphia, Wilmington

and Baltimore Railroad. They are equipped for the manufacture of all the standard sizes and shapes of sewer pipe, as well as of other work in terra cotta, and of fire-brick.

The material of which the pipes are made is composed of three ingredients—two kinds of clay, and a sand and clay mixed. The first is a very strong clay obtained from brick yards in the northeastern part of the city. It underlies the clay of which bricks are made. The second is a strong clay containing a red coloring matter, and is obtained from the south side of the Christiana River in New Castle Hundred, near the bridge on which the Delaware Railroad crosses the Christiana. The third ingredient is a material composed of fire-clay and sand, and is obtained on the Christiana River in New Castle Hundred. These ingredients are mixed in the proportion by measurement of two parts of the strong clay first mentioned, one part of the clay containing the red coloring matter, and one part of the fire-clay and sand. Made in these proportions the mixture is placed in the wet-pan, where water is added. The wet-pan is a shallow circular iron pan, in which the clays are crushed and mixed by two iron wheels, following each other on edge around the pan, driven by a horizontal axle attached to a vertical shaft. This pan is placed on the ground floor.

After the materials are properly mixed this clay is turned by a suspended shovel into the buckets of the elevator, which are attached to an endless band, in which it is raised to the third floor of the building.

Projecting from the third floor towards the second is the casting which contains the iron mould for the pipe. Into this the clay from the wet-pan is thrown, and an iron plunger, moved by the piston of a steam cylinder, which piston is attached to the upper end of the plunger rods, descends vertically, compressing the clay in the mould below.

After the clay is thoroughly compressed in the mould, an iron table under the mould, attached to the upper end of a piston passing below the second floor, and forming, as it were, the bottom for the mould, descends with the pipe standing upon it. The alternate upward and downward motions of the piston which moves the plunger, and the piston which moves the table,

are controlled by the operator on the second floor, where the pipes are removed from the mould.

Pipes under five inches in diameter are, when taken from the mould, immediately removed to another part of the second floor, where they have placed in them a wooden frame of the proper length, to which their ends are trimmed off and then smoothed with leather. As those over five inches in diameter come from the mould, they immediately have their spigot ends trimmed off, and are then taken by an elevator to the first floor where their ends are finished up. These, with the smaller pipes from the second floor, are placed on end on the drying floor of the first story of the building where they remain from three to six days, when they are ready for burning.

Branches are made by placing the branch piece, while damp, upon the main pipe, and then trimming and shaping them.

Traps are formed by hand in plaster of Paris moulds, which are made in halves, dividing lengthwise.

The walls of the kilns are of brick and are 13 inches in thickness. The kilns are circular, the largest being, inside, 22 feet in diameter, and 8 feet high to the square, surrounded by a dome.

The kiln is filled with pipes from the drying floor, placed on end. It is fired from eight fire-places at equal distances around the kiln. Gas coal is used. Inside, the products of combustion pass through short vertical stacks towards the top of the kiln, whence they are beaten back among the pipes, and finally escape through a flue built around the kiln near the bottom, and pass in an underground flue to the stack.

At the proper stage of burning, which is ascertained by small test pieces of clay which may be drawn and examined, the attendant passes three times around the kiln, and each time throws into each fire-place a shovelful of common salt. By this the pipes are glazed.

After the sealing of the kiln three days are required in which to fire up and burn, and three more in which to cool off and remove the pipes, which are inspected and are then ready for the market.

XXXV.

THE TESTING OF CEMENTS.

By A. Marichal, Active Member of the Club.

Read March 17th, 1888.

In entering a discussion upon the question of cements I expect to hear that the ground has been pretty well canvassed; that nothing new could be said on the subject; that engineers know all about it.

I must say that in many instances I have been able to convince myself of the fact that some engineers, in charge of very important works, knew little or nothing about the properties of cement. They spent many hundred dollars to test their cements; yet the mortar used in their works was not worth a penny. They did not test the mortar, but they tested the pure cement, and on no occasion was said cement used without the addition of sand. This seems to me very much like that amateur photographer who read somewhere that a solution of one part of sulphuric acid in one hundred parts of water was good to wash the hands in before developing; he wanted to know how good it was, and for this purpose washed his hands in pure sulphuric acid.

A material should be tested as near as possible in the same condition as it is used.

At a meeting of this Club on the 19th of November, 1887, I entered a discussion in order to prove that a cement giving the highest tensile strength when tested neat was not always the one having the highest tensile strength when mixed with sand. I will consequently not go into any more details about this question.

An engineer in charge of works requiring the use of cements should from time to time take samples of the mortar just as made by the mason and test it by some reliable method. Then he will be able to judge of the value of said mortar for the work he is doing. If the work is made under contract, the specifications should state the required properties of the mortar and *not the one of the cement.* A cement may be very good and yet the mortar

very poor because it has not been worked properly; the strength may be doubled and trebled by a good manipulation, a good proportion of water, a good quality of sand, etc.

The following experiment I had occasion to make seems to me very conclusive: I took Portland cement, mixed with two parts of sand, and made ten briquettes. Then I placed the remaining paste on a board in which I had drilled many holes. With a trowel I pressed the paste through the holes and made ten more briquettes. I repeated this operation four times.

I found that the average tensile strength of each series of briquettes was increasing and that the last series had a tensile strength of about 30 per cent. higher than the first one.

When the object is to determine the relative value of different brands of cements, care must be taken in making the briquettes and in testing them to have as nearly as possible all conditions alike; for instance, same manipulation, same proportion of sand and water, same temperature, etc.

Series of tests should be made with different proportions of sand. This point has its importance by the fact that some cements can be mixed with a greater quantity of sand and have still the same strength as another one mixed with a much smaller quantity. In many instances it will be found that the most expensive cement is the cheapest one after all, allowing the use of a greater proportion of sand.

The proportion of water has, within certain limits, but little effect on the ultimate strength of cements, when this one is not subject to pressure while setting.

On the contrary, if subject to pressure, a stiff paste will become stronger than a thin one. It has been my practice in building rubble masonry to pour fluid mortar between the stones in order to fill the holes as perfectly as possible, and I have been able to convince myself of the fact that this fluid mortar was as strong as the ordinary one placed under the stones.

As to the temperature, I must say that the importance results from the fact that the cements are generally tested after seven days—I mean after setting of short duration. After six months the difference resulting from the temperature is inappreciable, while after only seven days it may be 20 to 30 per cent.

In the machine generally used for testing cements the speed and uniformity in applying the load affects considerably the results. Some vibration is taking place, the intensity of which is different in all cases, hence lack of uniformity in the results. Several improvements have been suggested in order to avoid these vibrations, but none seems to me to be a radical one.

The best improvement I know of is realized by the "Buignet testing machine" operating by mercury pressure. The operation is as follows: A vessel containing mercury and adjustable at any height is in communication, by means of a rubber tube, with a chamber containing a floater. The mercury, being admitted into the chamber, gives to the floater an ascensional power, which is transmitted to a rod and multiplied by means of a combination of levers. The advantages are, first, in the uniformity accompanying the application of the load; second, in the almost total prevention of vibration.

Some cements increase in volume while setting when exposed to dampness. I know of several cases where this phenomenon has been the cause of the complete destruction of important works. In the case I refer to this increase of volume was due to the hydration of magnesia contained in excess in the cement.

It has been observed that an expansion of four per cent. was taking place in a cement pavement. The cement contained 25 to 30 per cent. of magnesia. It will always be safe practice to place some mortar in a glass tube and pour some water on top. If the glass breaks, the cement is unfit for use and should be analyzed.

The compressive strength of a cement mortar is of the greatest importance in ordinary constructions. Unfortunately it cannot be ascertained with any degree of accuracy; the mortar is injured before it is crushed, and it is impossible to tell exactly when it becomes injured. Moreover, it does not seem to exist in any definite relation between the tensile strength and the crushing strength. The proportion of sand seems particularly to affect this relation. As far as I have been able to judge, the cement mortar is injured when the crushing force becomes greater than six times the tensile strength, although I have seen some test pieces sustain nine times the same force without being apparently injured. For all

practical purposes I think that the coefficient 6 would answer very well.

I could go into many more details, but I think it is unnecessary. I have summarized the properties of cement which I thought were of practical use to the engineer in charge of masonry work, with a view of avoiding any waste of money in so-called tests of no value whatever and, may be, prevent the failure of the works.

Every year appropriations are made for public works all over the country; the percentage of these appropriations used for cement represents an immense capital. This capital belongs to the citizens, belongs to you; it should be expended in the most beneficial manner. Good cement should be bought; good mortar should be made with it.

But my voice is not strong enough to be heard, moreover I am not an authority on the subject; the Club is an authority and its voice will be heard. Consequently I take the liberty to ask for the appointment of a committee who would recommend a practical method of testing cement and present it to the Club for its approval.

XXXVI.

THE MANUFACTURE OF GUNPOWDER.

Prepared in part

By Frederic H. Robinson, Active Member of the Club.

Read March 17th, 1888.

The manufacture of gunpowder consists essentially in mixing the three ingredients, sulphur, saltpetre and charcoal, in such proportions that when heat is applied the whole becomes ignited, generating great heat, which expands the gases formed. The process is most complete when the substances are wholly converted into gases and vapors. The object is to have CO_2, not CO, formed. The latter arises from incomplete combustion. The gases come from the combination of the C of the charcoal with the O of the nitrate of potash. The S facilitates the liberation of the O combining with the metal, forming sulphuret of potassium.

Walking a few rods from the office of Du Pont's Powder Mills, Wilmington, Delaware, we entered the wood yard, where were great stacks of willow and poplar, part of which was already barked and stacked to dry. This wood, before being charred, is separated into two grades, the smaller of which contains mere branches, not more than an inch in diameter. For the manufacture of gunpowder the smaller wood is preferred, since it is easily charred so as not to leave any *O* behind, this precaution being necessary in the production of good gunpowder; since if any *O* remains combined with *H* so as to form water, such a large amount of heat will be absorbed by the water during the ignition of the powder that very little force will be given to the ball or shot. The coarse wood, mixed with the poplar, gives charcoal for blasting powder; since, though some of it be imperfectly charred, sufficient time is allowed such powder to undergo complete combustion before the expansion of the gases bursts the rock. A coarse-grained wood, as willow, is selected, because it requires but three or four hours to char it, while oak would consume a much longer time. All wood should be thoroughly dried before being charred.

In the coal house near by were five or six cast-iron cylindrical vessels containing the wood which was being charred. These retorts are sunk in an iron platform to such a depth that their lids are about five inches above the floor. The retorts are about four feet in diameter. Each one has a copper pipe in the lid for carrying off the pyroligneous acid, etc., formed during the process. The fire is kindled under these vessels. Up to about 150° F. the product of distillation tastes quite like distilled water; as the heat increases it begins to assume the taste of burned wood. The *H* is not entirely driven off unless the wood is subjected to a very high temperature. The presence of *H* is an advantage in powder used in shot-guns, as rapid combustion and the production of a high temperature are required. When the explosion takes place the heat, produced by the combination of this *H* with the *O* of the nitre, is very great. Hence the temperature for the charcoal for shot-gun powder is raised to only 480° F., and kept at that point for three and a half hours. For cannon or blasting powder it is raised to 600° F.

When the wood is sufficiently charred it is taken out of the retorts and placed in a room to be sorted. Here it is separated into three classes, one consisting of that which, from being in contact with the sides of the retort, has been too much charred. This class is distinguished by the very black, glossy surface. Another class, which has not been sufficiently charred, is of a light brown color. The third class, which is selected for shot-gun powder, is of a reddish brown. It is, however, entirely unfit for rifle powder, since it would produce too rapid combustion.

Next is the saltpetre department. Here the saltpetre in the crude state is separated from its impurities. Common salt and chloride of potassium, on account of their property of absorbing moisture, must, as far as possible, be gotten rid of. In order to do this, about 20 tons of saltpetre are placed in a vat standing about 15 feet high, in which it is subjected to the action of a constant stream of water. In cold water the chlorides dissolve first and escape through a pipe at the bottom of the vat. After several such washings the saltpetre is, to a great extent, freed from the common salt. The vat is shaped like the inverted frustum of a cone, and revolves about an axis. Six or eight feet from the vat is a large tank, so placed that about four feet of it stand above the level of the floor. When the salt has been separated, the contents of the wooden vat are emptied into this copper tank and dissolved in hot water. About two pounds of glue are dissolved in 200 pounds of cold water. This solution also is thrown into the tank. By stirring with a long rod the contents of the tank are thoroughly mixed. The cold solution of glue, chilling the nitre, causes it to settle, while the glue rises to the surface, clearing the nitre of mechanical impurities. It may be necessary to repeat this operation. If so, a weaker solution of glue must be used, since the nitre, being partly crystallized, would have a tendency to adhere to a strong solution. When this operation is completed, the nitre is removed from the tank to a long wooden trough and dissolved in hot water. The solution is kept stirred so as to cause the nitre to subside in minute crystals, thus avoiding the presence of the mother liquor, which, were large crystals formed, would, by capillary attraction, remain in their seams.

The nitre when deposited is removed from the mother liquor

and placed on a platform to drain. It is then washed to rid it of all the mother liquor. For this purpose it is placed in perforated wooden boxes, and distilled water is poured upon it. This water soaks through the mass and escapes through the bottoms of the boxes. At this point the purification, as far as chemical impurities are concerned, is ended. From the boxes it is removed to the drying mill. It is spread on a circular floor about 20 feet in diameter, and over it passes a large number of rollers. Alternate with these rollers are plows or scrapers which keep the nitre stirred. The water is evaporated by heat, communicated to the bottom of the floor. When thoroughly dried, which requires several hours, the nitre is passed through fine sieves.

The charcoal and sulphur are ground together. The two substances are placed in barrels in proper proportions. These barrels have horizontal shafts passing through them from end to end, about which they revolve. There are about a dozen of these barrels on one shaft, and in each barrel is a number of malleable iron balls. As the barrels revolve the balls falling about crush the charcoal and sulphur to the proper degree of fineness. The pulverized mixture is passed through a sieve to remove the coarse pieces of charcoal.

From this mill the powdered charcoal and sulphur are taken to the incorporating mill, where they are mixed with the proper proportion of the prepared saltpetre. The mixture, together with a number of zinc balls, is then placed in barrels made of buckskin, stretched on frames. These barrels are driven in a manner similar to that in which those used in crushing the charcoal are driven. Since there is a small amount of moisture in the ingredients, it is necessary, while the barrels are revolving, that care should be taken that the powder does not adhere to the sides. If it should, the accumulation of the powder might hold the balls in its mass, forming, as it were, a fly-wheel. In order to prevent this accumulation the sides of the barrel are struck with a wooden mallet. The operation going on in the barrels is for the purpose of producing a homogeneous mixture of the three ingredients.

When thoroughly incorporated, the powder is taken to a building where it is mixed with water—in winter 3½ per cent., in summer 4 per cent.

The powder is then ground. It is so spread over the bed of the mill as to cover it to the depth of two or three inches. There are two large cast-iron edge wheels, each weighing eight tons. These, which are driven by an upright shaft, move over the powder, grinding it to a high degree of fineness. There are at one time only about 100 pounds of powder in each of these grinding mills, so that if an explosion should occur in one of them, injury to the neighboring mills would be avoided.

After being ground the powder is removed to the pressing mill, where it is subjected to a pressure of 2,000 pounds to the square inch. After being pressed it is very hard, and in the form of square cakes about two feet square and one inch thick. These are passed between rollers upon which are cogs of bell metal. This is merely preparatory to the granulating operation, which consists in passing the broken cake through rollers. These rollers are placed at a distance from each other, varying according to the size of the grain to be prepared. As the powder passes between them it falls upon a series of sieves. The part which passes through the first sieve falls upon another, which retains the proper sized grains, allowing the rest to pass through. That portion not sufficiently fine is again passed through the rollers. That which is too fine is returned to the mill to be again pressed.

The next operation is the glazing of the grains. The powder is placed in barrels. As the barrels revolve upon horizontal axes, the friction of the grains against each other leaves the powder glazed and ready to be dried. For this purpose it is placed in bags and taken to the drying-house. In a room is a frame work, upon which the sieves containing the powder to be dried are placed. After remaining here about eleven hours it is removed to another building where it is packed, and from which it is shipped to the various markets.

DISCUSSION.

By J. W. Redway.

Read March 17th, 1888.

The following summary of results concerning the explosion of powder and the chemical reaction which occurs during the process was presented by Mr. J. W. Redway.

The explosion of powder is nothing more than the ordinary phenomenon of combustion—that is, the combination of carbon with oxygen to form carbon dioxide. The only difference is that in ordinary combustion the oxygen occurs diluted with four times its volume of nitrogen. In the combustion of gunpowder, not only is the oxygen undiluted, but it is chemically compressed to about one-three-hundredth part of its normal volume. This is the secret of the dynamics of a gunpowder explosion. This is why a gunpowder explosion develops a force so much greater than one of carbon "dust" or of coal-gas.

The average gunpowder consists of about 75 parts of potassium nitrate, 12 of sulphur and 13 of charcoal. This corresponds nearly to the chemical formula:

$$2\ KNO_3 + S + 3\ C = K_2S + 2\ N + 3\ CO_2.$$

This has long been considered the chemical reaction of the explosion. The real reaction, however, is far more complex.

A number of analyses of the residues of explosion or combustion, made in part by the writer, he having undertaken the investigation of the solids, showed the following average results in round numbers. These analyses closely confirmed the results obtained by Abel and Noble.

SOLIDS.		GASEOUS.	
Potassium Carbonate	.55	Carbon Dioxide	.49
do. Sulphate	.15	Carbon Monoxide	.09
do. Hyposulphite	.20	Nitrogen	.36
do. Sulphide	.07	Hydrogen Sulphide	.04
Ammoniacal and other products	.03	Other products	.02
	1.00		1.00

There is much variation in the composition of the solid residues, even when the powder is ignited in a vacuum, but inasmuch as powder is composed of elements of strong affinities, a now uniformity of the percentage of products might be expected. The composition of the gaseous products are more uniform than that of the solids.

The volume of the permanent gases reduced to normal tension (one atmosphere) and temperature is from 275 to 290 times the volume of the powder. If the chamber containing the powder

is entirely filled, the tension of the liberated gases varies from 31 to 37 tons per square inch, the theoretical pressure being about 42 tons per square inch, with the gases reduced to normal tension and temperature.

But the temperature of the elements at the time of explosion may be safely estimated at 2,200° C., and therefore the volume of the liberated gases will exceed the values already noted, being nearly eight times as great theoretically.

Practically all of these values must be taken with more or less allowance, as all analyses, physical, chemical and dynamic, demonstrated that inconstancy of result was one of the most noticeable factors.

The explosion of nitro-glycerine is wholly unlike that of gunpowder. The latter is reaction and combination; the former, molecular disintegration.

A molecule of glycerine, a very stable substance, may be represented by the formula $C_3\ H_8\ O_3$. If, however, we allow a fine stream of glycerine to trickle into a vessel containing red, fuming nitric acid, it undergoes a remarkable change. These atoms of hydrogen are dropped, and in their place the glycerine takes up three molecules of a nitrogen compound having the composition NO_2. The glycerine, in other words, has become nitro-glycerine and has the formula $C_3\ H_5\ (NO_2)_3\ O_3$, and it is marked by extreme instability. It is like a boiler with a pressure the merest trifle below the bursting point—a slight percussion and the bands are broken. There is no combination of atoms in the nitro-glycerine explosion. The molecule merely falls to pieces. It does so *instantly*, and nine hundred volumes of gaseous products, chiefly carbon dioxide and nitrogen tetroxide, resume their normal condition. In other words, the gaseous products have nine hundred times the volume of the nitro-glycerine. This, together with the instantaneity of the explosion, may explain why nitro-glycerine is so much more destructive in its effects than black powder.

XXXVII.

THE ITEMS OF EXPENSE IN INCANDESCENT ELECTRIC LIGHTING.

By Lino F. Rondinella, Active Member of the Club.

Read March 17th, 1888.

The total expense in incandescent electric lighting is made up of the two items of *power* and the *renewal of lamps.* To reduce this expense to a minimum, the manufacturers of incandescent lamps have therefore directed their efforts to improving them in two different particulars. In the first place the *efficiency* of the light must be increased, that is, the amount of motive power expended on the dynamo, to produce one candle-power of light in the lamp, must be as small as possible. And in the second place, the *duration* or life of the lamp must be lengthened.

Now it has been a comparatively easy matter to realize either of these conditions separately,—to make a lamp of high efficiency, or to make one of long duration. One maker may truthfully tell you that his lamp is the most efficient in the market, perhaps that it requires only about three watts of power per candle of illumination, which would enable you to run about fifteen 16-C. P. lamps to the horse-power. Another maker may say, quite as truthfully, that his lamp will last longer than any other kind—several thousand hours, perhaps—and that the expense of renewals will therefore be a minimum. The first man will make no remark on the durability of his lamp, while the second will be silent on the subject of efficiency. The fact of the matter is that it has been found impossible, as yet, to combine very high values of both efficiency and duration in one and the same lamp. It becomes an interesting question, then, to consider *what relation exists between these two properties in incandescent lamps;* and if we can answer that, it will be easy to decide whether the more efficient or the more durable lamp is the more economical in the end.

After the Electrical Exhibition of 1884, a special committee of the Franklin Institute made a very careful series of tests on the

efficiency and duration of seven different kinds of incandescent lamps submitted for the purpose. The principal conclusions to be drawn from their report are, that—

The twenty* Edison lamps showed next to the lowest average efficiency and the greatest durability. They were the most regular in both respects. Nineteen lamps lasted the full 1,065 hours of test; one broke after 295 hours.

The ten 96-volt Stanley lamps stood fourth in average efficiency. Only one lasted 1,065 hours, the others from 78 to 882 hours.

The ten 44-volt Stanley lamps showed the highest average efficiency, but were irregular. One lamp survived 1,047 hours; the others broke in 40 to 309 hours.

The nineteen 55-volt Woodhouse & Rawson lamps stood second in the average and regularity of their efficiencies. Ten of them, submitted to the 1,065-hour test, broke in 41 to 716 hours. Four of the remaining nine survived a 331-hour test.

The ten 50-volt White lamps stood fifth in average efficiency, and varied considerably. Seven of them survived a test of 310 hours.

The twenty 110½-volt Weston lamps stood third in average efficiency, but were the most irregular. Seven of them survived the 1,065-hour test; the others varied in duration from 41 to 823 hours.

The ten 70-volt Weston lamps showed the lowest average efficiency, but varied considerably from each other. Seven of them survived a test of 523 hours.

It is but fair to mention that after the efficiency tests Mr. Weston stated that the filaments in his 110½-volt lamps had been very imperfectly prepared, and unsuccessful efforts were made to withdraw them from the duration test.

The Franklin Institute tests were conducted for efficiency and for duration separately, and no remark was made on any relation which might exist between those two properties. Although the lamps tested covered a wide range in both particulars, and although the data for each lamp is very comprehensive, there were not enough lamps of each different grade to admit of the

* The number tested for *both* efficiency and duration.

results being used as material from which to discover such a relation. Through the kindness of Professor Wm. D. Marks, of the Edison Electric Light Company, however, I was fortunate enough to obtain a quantity of data that had been worked up from the results of several thousand lamps used in regular service in many different plants during a period of five years. This gave the *life* averages of Edison lamps for all grades of *efficiency* from 2.5 to 4 watts per candle. Corresponding values, when plotted as co-ordinates from two perpendicular axes, gave such a regular looking curve that the thought at once struck me that it might be possible to find a constant equation for it, an equation that would show a fixed relation between efficiency and duration, in Edison lamps at least.

The form $h = cw$ (in which h is the hours of life, and w the corresponding watts per candle, and c and x are constants) was suggested to me, and after making several series of calculations with different assumed values for x and the values of h and w that had been plotted in the curve, I finally succeeded in finding a value of x that gave a constant value to c for every point in the curve between 800 and 100 hours—the values for the few points below 100 hours being very slightly different. Substituting these values for the constants in the original form, the equation thus found for the relation between efficiency and duration in Edison incandescent lamps is

$$h = \frac{w^{5.7725}}{3.7349}$$

The table below contains values for efficiency and life that were calculated by this formula, and that agree exactly with the original data, except for 50 and 75 hours, as suggested before. The corresponding candles per horse-power, and the number of 16-candle lamps per horse-power, are added in the table.

All of the figures in the table, it will be remembered, were obtained originally from Edison lamps. In the effort to find out whether the same or an equally constant relation exists between efficiency and life in incandescent lamps of other companies, I have made application to several of the more important for data of the average lives of their lamps of different grades of efficiency,

TABLE.

Efficiency, Duration, Illumination.

Watts per Candle.	Life in Hours.	Candles per H. P.	16-C. P. Lamps per H. P.
2.474	50	301.5	18.85
2.654	75	281.0	17.55
2.790	100	267.4	16.70
2.993	150	249.2	15.60
3.146	200	237.1	14.80
3.270	250	228.1	14.25
3.375	300	221.0	13.80
3.466	350	215.2	13.45
3.547	400	210.3	13.15
3.620	450	206.0	12.90
3.687	500	202.3	12.65
3.749	550	199.0	12.45
3.805	600	196.0	12.25
3.859	650	193.3	12.10
3.908	700	190.9	11.95
3.955	750	188.6	11.80
4.000	800	186.5	11.65
4.042	850	184.6	11.55
4.082	900	182.7	11.40
4.121	950	181.0	11.30
4.158	1000	179.4	11.20
4.193	1050	177.9	11.10
4.227	1100	176.5	11.05
4.259	1150	175.1	10.95
4.291	1200	173.9	10.85
4.321	1250	172.6	10.80
4.351	1300	171.5	10.70
4.379	1350	170.3	10.65
4.407	1400	169.3	10.60
4.434	1450	168.2	10.50
4.460	1500	167.3	10.45

and received answer that they have not enough data of that kind to make it sufficiently reliable for my purpose.

Turning then again to the Franklin Institute tests as the only other available source of information, I decided to try how all of those six different kinds of lamps (the Edison were, of course, excluded), considered collectively, would agree with the values in the table, and obtained the following interesting and rather suggestive results.

According to the table, a lamp that requires only 2.99 watts per candle should live 150 hours. Of the five lamps in the test, whose efficiency was equal to or greater than this, only one lasted more than 150 hours, and it broke in 206 hours.

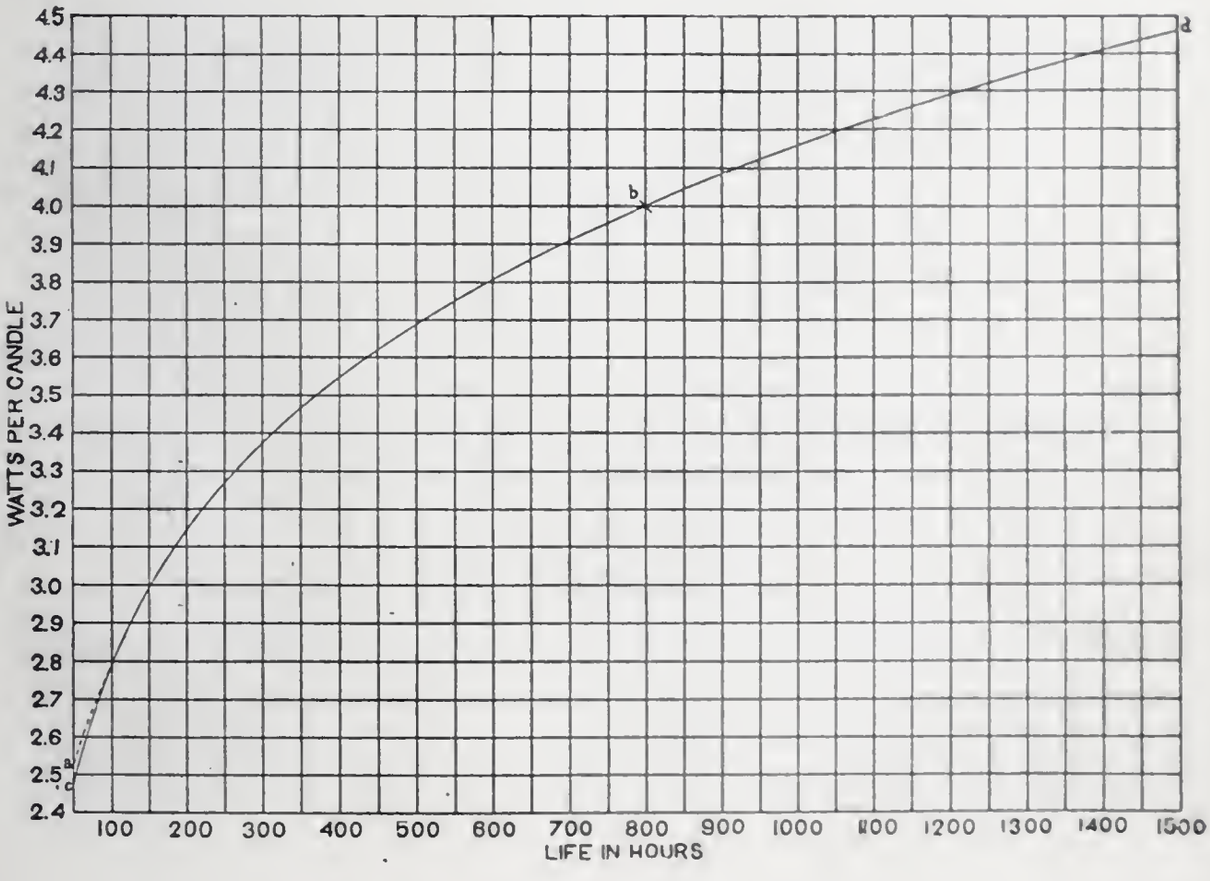
A lamp requiring 3.37 watts per candle should live 300 hours. Of twenty-two lamps in the test, whose efficiency was equal to or greater than this, six lasted more than 300 hours,—one of them 300½ hours, the others 330, 422, 823, and two Weston lamps each 1,064 hours.

A lamp requiring 3.8 watts per candle should live 600 hours. Of forty-six lamps in the test, whose efficiency was equal to or greater than this, eight lasted a longer time—715, 823, 881, and five 1,064 hours.

These facts make it seem likely that the formula for Edison lamps will apply quite closely to other incandescent lamps, and show also that it is a mistake to expect long life from lamps of very high efficiency. There is no doubt that future improvements in the carbon filaments will increase the durability of high efficiency lamps, but *maximum* values of efficiency and life can never be found in a single lamp, notwithstanding the statement in some electric lighting catalogues to the contrary.

The curve *ab*, in Fig. 1, shows the values for *watts* and *hours* that were contained in the original data, while the curve *cd* is plotted from the *calculated* values in the first two columns of the table.

Fig. 1.



Let us see now whether a lamp of high or low efficiency is the more economical. If the cost of 1 H.P. be 1 cent per hour, and the cost of each new lamp be 85 cents, and we select for comparison a low-efficiency 16-C.P. lamp that requires 4.16 watts per candle and lasts 1,000 hours, and a high-efficiency 16-C.P. lamp that requires 3.69 watts per candle and lasts 500 hours, the expense of running each lamp 2,000 hours will be made up as follows:

In the low-efficiency lamp:

$$\text{Cost of Power} = \frac{4.16 \times 16 \times 2000}{746} \text{cents} = \$1.78$$

$$\text{“ “ 2 Lamp Renewals @ 85 “} = 1.70$$

$$\text{Total Cost} = \$3.48$$

In the high-efficiency lamp:

$$\text{Cost of Power} = \frac{3.69 \times 16 \times 2000}{746} \text{cents} = \$1.58$$

$$\text{“ “ 4 Lamp Renewals @ 85 “} = 3.40$$

$$\text{Total Cost} = \$4.98$$

showing a saving of $1.50 in 2,000 hours in favor of the lamp of lower efficiency and longer life,—an item of considerable importance in calculating the cost of running an electric lighting plant. At 10 cents per H.P. per hour, the balance changes in favor of the high-efficiency lamp; *it* would be the more economical lamp to use therefore in localities where power is very expensive.

It will not be very long before those living in the central part of Philadelphia can be supplied with incandescent electric light from a central station in the same manner as they are now supplied with gas; indeed, a few squares in the business centre are already being supplied in that way from the station of the Keystone Light and Power Company. The Edison Electric Light Company's mammoth station (it will be the largest station in the world) will probably be running by next fall, and will furnish light and power to the greater part of the district included between Walnut and Market Streets, from the Delaware to the Schuylkill, subse-

quently extending further north and south. The cost of illumination by incandescent lights, fed from either of these stations, although their methods of charging differ, is about the same as the present cost of illumination by gas at $1.50 per thousand feet. The Keystone Company charge a fixed price of $1.25 a month for each 16-candle lamp, whether the customer uses it much or little. As they only supply business houses, they calculate that each light is used on an average 5 hours on each working day, or about 130 hours a month. The Edison Company charge for the exact amount of electricity used as registered by a meter in the consumer's cellar, their rate being stated as equal to gas at $2.25 per thousand. This rate is based on the theory that a gas burner using 5 cubic feet per hour gives a 16-candle illumination, while, as an actual fact, it only gives 9 or 10 candles. If we use as realized values 10 candles for a 5-foot gas burner, and 16 candles for an incandescent lamp, a few simple calculations will give us, as the comparative cost per candle-power per hour,

	for gas light	= .075	cents.
(Edison Company),	incandescent "	= .0703	"
(Keystone "),	" "	= .0601	"

Though it remains to be seen whether the incandescent light will supplant gas in the same way that gas has supplanted oil, there is no doubt that in the near future it will play a very important part in interior illumination.

XXXVIII.

ROPE OR CABLE AS A TRANSMITTER OF POWER.

By Wm. H. Robinson, Active Member of the Club.

Read April 7th, 1888.

Mr. President and Fellow Members of the Club:—Allow me to call your attention for a few moments to a subject that is more or less familiar to all of you, and yet may have some points sufficiently interesting at this time to not bore you with its mention.

The subject of power transmission by the cable is by no means a new one, but of late years it has taken a new and decidedly vigorous hold upon city railway owners in many of the principal cities in all civilized countries; and to-day we find one or more roads where it is used as a medium of transmission in almost every large city. Capital seems ready and willing to adopt this mode of propulsion in preference to many others, as it promises, when it is once properly constructed, to be both economical in its maintenance and durable.

Many thousands of dollars have been spent by the pioneers in this mode of transmission of power (or traction, as it is improperly called) in overcoming the faulty construction of the earlier devices used in its application to car propulsion upon our streets.

We are all familiar with the innumerable delays passengers upon the roads in this city were subjected to in its early use; when one was anxious to reach a desired destination it frequently became necessary to finish the journey on foot. Those delays and stoppages are rapidly becoming less frequent and of shorter duration, as the old appliances are being replaced and defects in construction rectified, which the able management of our home companies are so successfully accomplishing. To them must be accorded due credit for making a success of what promised at first to be disaster and defeat.

The propulsion of cars through the streets of our cities on the surface roads, by the use of the cable, will no doubt be continued until some better mode shall be developed.

It does not furnish that rapid transit so desirable in cities like Philadelphia, but all things considered it is a decided improvement over the old horse cars, and until something better is proposed and adopted, we must be content with its performances. It is likely for a while at least to be the favorite medium, and could, under proper conditions, be made to furnish reasonably rapid transit.

Much has been accomplished within a very few years to make rope hauling on our streets a profitable and successful fact, yet much remains to be done. Many changes will yet be made before the application can be relied upon with a reasonable

degree of certainty to the stockholders and satisfaction to their patrons.

I am not here to-night to attempt to detract one particle of credit from the engineers who have labored in this field in its early days and battled with the inexperience of the necessary appliances without precedent. They have accomplished all that could reasonably have been expected from men laboring in a new and untried field.

I desire to lay before you some thoughts and observations that entered into my own experience and practice in the use of rope as a medium of transmission.

In 1857 I was appointed by the Delaware & Hudson Canal Company to superintend the mechanical construction of their inclined planes machinery at Carbondale. This consists of eight inclined planes, operated by eight pairs of engines, and eight pairs of drums, 10 feet diameter and 10 feet face, over which an endless rope is operated in grooves cut spirally upon the periphery, which causes the rope to move across the face of the drum in its ascent or descent on the plane. These planes are so situated that the loaded cars are drawn up each successive plane until they reach the summit of the mountain, when they are made to run by gravity down the opposite side to Honesdale, a distance of 16 miles, where the coal is there put into boats. The empty cars are returned in the same manner after being unloaded; they are raised to a convenient height at Honesdale, and start on their return trip; they travel by gravity for a distance of four miles, reach plane No. 2, and are again raised to a height that carries them to plane No. 3, which is the last lift on the return trip; they travel by gravity about 20 miles back to the mines at Carbondale.

Here, then, I had my first experience with rope hauling. I became deeply interested in its performances; and have been watching its actions with increasing interest whenever any new features are presented or occasion requires any thought to be given it.

I have here a drawing or print of the plan in general use on all rope roads in this and other countries, with various modifications to suit the views of the different engineers engaged in their

construction. They all employ the solid drum and idler, or intermediate drum, as shown upon this print. The rope takes 2, 3, 4, 5 or 6 turns around each drum in grooves turned on their periphery, which gives it the necessary adhesion to do the work. From the drum it passes around a one-grooved sheave, supported upon a tension car to take up all slack and keep it in proper condition to at all times respond to calls made upon it by the cars when attached.

This mode of application is practically the same used by all roads in operation to-day, and while it seems to answer tolerably well in its general arrangements and convenience, it is not without some serious defects, and is the direct cause of many breakages from the fact that it is utterly impossible to keep the grooves alike in diameter for any great length of time. The differential principle so plainly apparent in all cases where two or more turns are made to pass around drums located as for driving rope in these cases before us is terribly augmented after the first few hours' run, and continues a suicidal strife, if not corrected, until one or the other must give way; either the rope will part, the drum will break, or the shaft be twisted off. No one need for a moment doubt the terrible strife at work on drums arranged in this way; it is but necessary to watch them while in motion to be fully convinced of the suicidal battle going on; and if it be not corrected it will most surely cause disaster.

Many attempts have been made to correct this evil, many devices have been tried; but none appear to answer as well as to set up a slide rest and restore all of the grooves to the same diameter.

The Brooklyn Bridge is a prominent case in point. Its machinery was originally constructed on this plan; it has the two solid drums, with a large spur-wheel on each drum shaft, and a pinion between them which is upon the engine shaft. Several serious breaks have occurred, new drums have been put in at two different times, and no doubt other mishaps have occurred of which we know nothing. There are some changes being made to the machinery at this time, but I do not know the nature of them.

It matters not how correctly a pair of drums may be turned originally, or how accurately all work may be set up, the cable

will assert its right to slip over the surface when one turn around the drum gets more strain than another, which is due to several causes, of which more will be said hereafter.

I will here say that all endless ropes traveling over a route of considerable length do not only move in their longitudinal course, but they also have a rotary motion upon their own axis as well, more or less accelerated according to circumstances surrounding them. Those used in car propulsion are necessarily very long and pass through their route on supporting pulleys at convenient distances apart, and around all curves on a number of small pulleys placed at suitable distances apart to form the curve. This then becomes one important factor in imparting a rotary motion to the cable.

The twist of the rope itself with the necessary tension upon it tends to give it an unrest and inclination to turn, and often causes it to move in that direction; but now a grip comes slipping along, adding to the number of turns, by reason of the twist of the rope and not being held rigidly in its grasp; passing a curve deposits the accumulation on the other side, and is ready to repeat the operation every time it grasps and lets go the cable. When the driving station is reached, whatever number of revolutions may have accumulated on the route of the rope, from the time it left the station until it returns to it again, are from necessity taken in over the drum, and must necessarily make a disturbance among the laps upon it from the fact of being shorter by reason of the twist carried with it when it touches the first groove in the driving drum. These laps are thrown into confusion, so to speak, but strive hard to equalize themselves, and the consequence is a continual fight upon the periphery of the drum, and both drum and rope must suffer the consequence. This strife upon the periphery of the drums is easily discernible; a man need not be an expert in the matter and fully acquainted with the actions of the machinery in use. All that will be necessary to convince any one of it will be to observe the actions of the different laps as they pass the space between the drums; some will show a decided looseness, while others will be as tight and rigid as though they were a solid bar of iron without motion; it will not always be the same strand of rope that will

show the greatest looseness, but as the strains upon the strands are equalized, the tension changes from one to the other alternately.

Again, this equalizing operation can be distinctly heard when the strand takes its new position upon the drum; a continual clicking noise, and a dull sound of a heavy weight adjusting itself from an uneasy position, is plainly observable and will often arrest the attention of a passer-by, who may have no knowledge whatever of the cause.

I have here another representation of a pair of drums, or more properly speaking a solid drum, and an intermediate one composed of parts or sheaves representing the same number of grooves as are contained in the driving drum, but so constructed that each strand of the rope is free to carry the sheave over which it passes at whatever speed may be required independently of its neighbor. They are all upon the same shaft; one only being keyed fast to it, in order to carry it around at the speed of the driving drum.

This, then, reduces the wear and tear of all the sheaves upon the shaft to a very small amount, as it is plainly observable that the difference in their *relative* motion will at times be scarcely perceptible, but they are free to move if the strain upon any one strand of the rope requires a change of position upon the shaft.

I do not claim to entirely overcome the slipping propensity of the rope over the drum, but it is brought to a minimum, and the very important result is gained of having equal tension upon every strand around the drum, thereby removing much of the strife and prolonging the life of the *cable.*

This drawing fully represents the nature of the construction, and can with but few changes be made to take the place of any intermediate now in use on any rope road of which I have any knowledge.

They are all suffering from the same cause, but having applied the old solid drums are slow to see any merit in anything different; and as they are willing to foot the bills for new *rope* and broken *machinery,* I cannot see that it is any of our business.

XXXIX.

THE EFFECTS OF GASES, ETC., FROM STACKS UPON IRON.

By C. A. Preston, Active Member of the Club.

Read April 7th, 1888.

To-day I send some samples of bridge iron that have been affected by gases, etc., proceeding from stacks of locomotive engines. The iron is from Charles Street Bridge, which was over Northern Central Railway tracks at Union Station, Baltimore. The bridge was a Pratt Truss, of one span, erected in 1870, and replaced this month by a $\frac{1}{2}$ thro. plate girder of three spans. The bridge was at the head of Union Freight Yard, and trains were being constantly shifted under north end of bridge; few trains passed under the south end. Floor level is 18 feet $9\frac{1}{2}$ inches above top of rail. Actual clearance is 17 feet $3\frac{3}{8}$ inches above top of rail. Top of locomotive stack above top of rail is 15 feet. Account was kept of engines passing under north end of bridge, where greatest depreciation of iron is shown, and the average is not less than 700 each twenty-four hours.

The gases, etc., from the stacks are under pressure; lowest point of bridge was only 2 feet $3\frac{3}{8}$ inches from top of stack.

Samples* marked A and A^1 are pieces of lower chord, A being taken from south end of bridge, and is nearly the original section; A^1 being from north end of bridge. Depreciation about 42 per cent.

B is a bolt which connected wooden floor beams and iron **I** beams. The part that passed through the wood is about $\frac{3}{4}$ inch in diameter, the part between the **I** beams and exposed, about $\frac{1}{4}$ inch diameter. Depreciation about 87 per cent.

Samples marked C and C^1 are parts of lateral rods. These rods were originally $\frac{7}{8}$ inch diameter. C was taken from south end of bridge and is nearly the original section. C^1 about $\frac{1}{4}$ inch in diameter was taken from north end. Depreciation about 90 per cent.

I am unable to suggest any *practical* method of overcoming the effect of these gases.

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* Samples may be seen at Club House.

XL.

NOTES ON TWO EXPERIMENTS WITH CEMENT MORTAR.

By Herbert Bamber, Active Member of the Club.

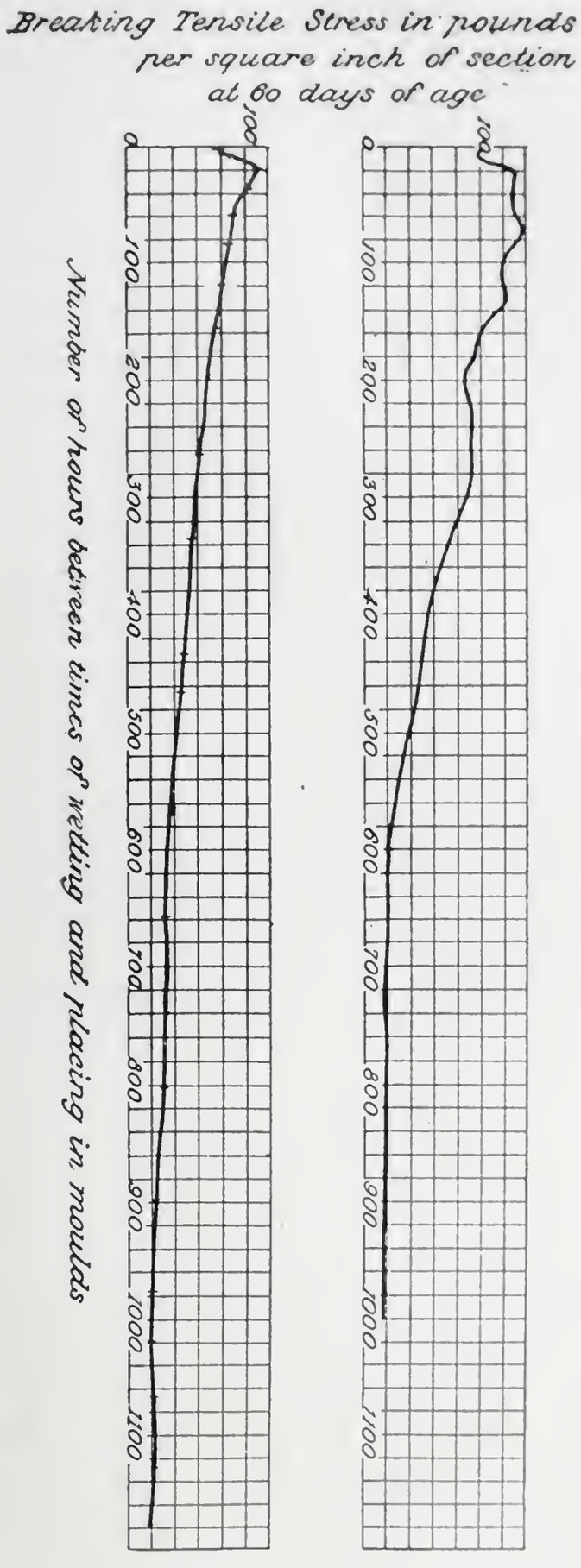
Read April 7th, 1888.

The mortar for the first experiment was composed of equal quantities of Rosendale cement and good sharp sand. Immediately after tempering a set of briquettes was moulded. The remaining mortar was then worked over sufficiently often to prevent any decided indications of the commencement of setting, water being added to compensate for that lost by evaporation, and briquettes moulded in sets at increasing intervals for a period of about forty-two days.

These briquettes were left in the air and tested when sixty days of age. The upper of the two curves was plotted from the tensile stresses at which these briquettes broke, and it shows that the maximum strength of the mortar was obtained by keeping it in a plastic condition for about seventy-two hours before allowing it to set.

The mortar for the second experiment was also composed of equal parts of Rosendale cement and sand. After the first set of briquettes was moulded, it was allowed to set so that it would bear the usual test of a weight of four ounces on a wire one-twelfth of an inch in diameter, then it was retempered and another set of briquettes moulded. This operation was repeated twenty-one times, the repetitions extending over a period of about forty-nine days.

These briquettes were also left in the air and tested when sixty days of age. The lower of the two curves was plotted from the results of these tests, and it shows that the strongest briquettes were those moulded from the mortar after it had both set and been retempered three times.


Breaking Tensile Stress in pounds per square inch of section at 60 days of age
100
0
100
200
300
400
500
600
700
800
900
1000
1100
Number of hours between times of wetting and placing in moulds

XLI.

NOTES ON THE PHYSICAL PHENOMENA OF LAKE HARBORS.

Contributed to the Proceedings of the Engineers' Club of Philadelphia by Mr. Geo. Y. Wisner, Member of the American Society of Civil Engineers, formerly Assistant Engineer United States Lake Survey.

Read April 7th, 1888.

A study of the physical features of sea-coast harbors reveals certain typical forms of channels and bars, which depend for their uniformity upon the action of the tides and currents flowing under similar conditions.* On the lakes where no appreciable tides exist, it has been assumed by many of the engineers who have had charge of the various works of harbor improvements, that the movement of drift and the formation of bars were entirely dependent on wind-wave action, and that the laws governing such formation had no analogy to those existing on a tidal coast. A comparison of the entrances of lake harbors with those on the sea coast shows such striking resemblances in contour lines and shape of bars, that the inference at once arises that the same general laws of nature exist in each case.

On certain portions of the lake coasts the rivers, instead of being normal to the shore, flow for considerable distances parallel to the coast and then empty into the lake through channels of the same general direction; while on other portions of the same lake coast, and under the action of similar prevailing winds, the tendency of the streams is to empty into lakes through channels bending in the opposite direction.

The improvement of mouths of rivers for harbor purposes has usually been accomplished by building parallel piers from deep water in the river to deep water in the lake. The result of these works on the lake action has been to form an accumulation of drift on one side of the piers, and a movement of the crest of the bar into deeper water. On any given coast it may easily be predicted on which side of a pier drift will accumulate.

* See "Physical Phenomena of Harbor Entrances," by Lewis M. Haupt, C.E. Proceedings, American Philosophical Society, Phila., 1888.

Strong littoral currents also exist along the shores, varying in directions and intensity according to locality and conformation of coast line. Near the head of Lake Michigan, for instance, these currents are southerly along each shore. About midway of the coast, on either side of the lake, they are found flowing sometimes in one direction, and then again in the opposite, while farther down the coast the currents are almost continuously northerly. The flexure of mouths of rivers and shape of bars conform in every instance to that which might be expected under the action of natural forces tending to produce such currents.

Lake harbors, consisting of small bays with outlying islands and gravel bars have the same general characteristics as those on the Atlantic coast. The spits and bars forming the lake side of the harbors usually have elongated points, curving inwards on one side of the entrance, and a well-rounded point on the opposite side. Gradual erosion goes on continuously along the blunt point, while the sharp point follows, leaving the natural cross-section of the channel in the gorge the same from year to year.

These natural characteristics are well illustrated at the Harbor of Grand Marais, Lake Superior, where the forces of nature, if properly assisted, would make one of the grandest harbors on the whole chain of lakes, but which, under the plans adopted (estimated to cost $500,000), will at best prove but a doubtful experiment. See Plate 1.

Major Robert, in a report to the Chief of Engineers, January, 1881, in speaking of the changes that had occurred at the above harbor since the previous survey made in 1867, says: "The only thing learned by investigating these changes that affect the construction of the piers at the proposed site, is that there is a large amount of shore drift, which will in the future require the *piers to be extended, as has been found necessary at nearly all the harbors on Lake Michigan.*" . . .

"To facilitate entering the channel, it is proposed to extend the piers to a depth 4 feet greater than that of the channel. As the shore drift is very large, there will not be 24 feet of water at the end of the piers when they are finished as proposed. If completed in ten years, however, it is believed that there will be over 20 feet of water at the head of the piers where there is now 24 feet."

Mr. L. Y. Shermerhorn, in a report, Jan., 1881, says in regard to the above harbor: "A comparison of the west spit as it now exists, with its position as determined by the lake survey of 1867, shows that the east end of the spit has advanced into the bay 400 feet, and placing the end of the spit now where in 1867 there was a depth of water of 55 feet. This advance of the west spit since 1867 has been accomplished by the deposition of about 500,000 cubic yards of material, and seems to be a measure of the larger amount of shore drift at this point. . . . The advance of the west spit has been accompanied with the retrocession of the east spit for a distance of 300 feet. Borings indicate that the lake bed north of the west spit is composed of sand, gravel and coarse drift, superimposed on a bed of clay."

The drift formation in front of this harbor indicates that at some early date it was simply an indentation of the coast line, and that the accumulation of drift has closed the opening, until the forces of nature tending to maintain an open channel from the harbor to the lake are in equilibrium with those tending to close it.

As no great amount of water flows into this harbor from its natural drainage area, the question arises, why has not this immense amount of drift, in connection with wave action, closed this entrance years ago.

In 1883 a single storm completely closed a 12-foot channel dredged through the spit between the piers (see Plate 1), and still the natural entrance has retained approximately the same cross-section that it had 60 years ago when Bayfield made his survey. Were no other forces acting at this point than those due to wave action, this entrance would be completely closed in a single season.

As is well known, the area of the great lakes lie in a region subject to very sudden and great barometrical disturbances. These barometric inequalities of pressure on the lake surface set in motion series of oscillations varying from 6 inches to 2 feet in amplitude, and with intervals of 20 minutes to $1\frac{1}{2}$ hours between crests depending on locality of disturbing force and the conformation of the coast line.* In extreme cases waves of this character have

* See "Observations on the Oscillations of Lake Michigan," by Rudolph Hering, printed in Vol. VI, No. 2, Proceedings of Engineers' Club of Phila., March, 1887.

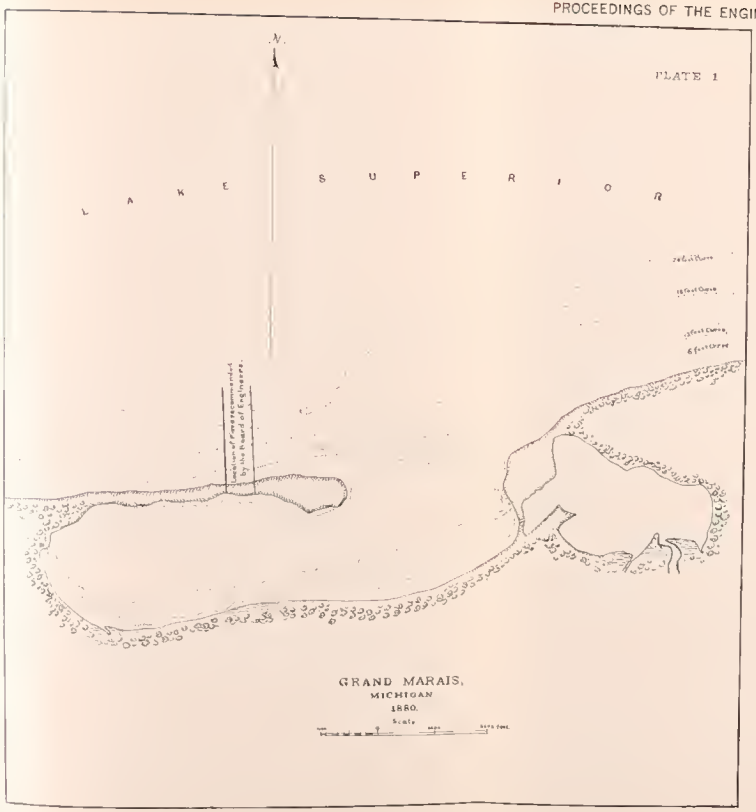

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PLATE 1
L A K E S U P E R I O R
GRAND MARAIS,
MICHIGAN
1880.
Scale

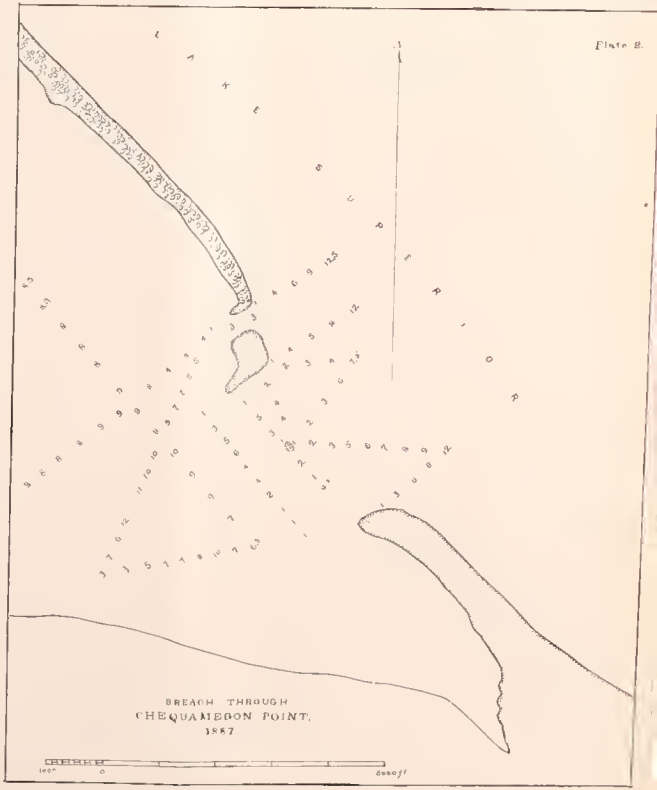


Plate 2.
L A K E S U P E R I O R
BREACH THROUGH
CHEQUAMEGON POINT,
1887

been observed on Lake Superior, with crests 5 feet above the general level of the lake surface.

From observations of these oscillations, extending through a period of over twenty years, I have found that the average oscillations in many places is not far from one foot. At Grand Marais Harbor (Plate 1), it is often as much as 18 inches, with intervals of about one hour between crests of waves. The oscillations at the above place approach the shore from the northwest, producing a strong littoral current to the eastward, and a constant *ebb* and *flow* between lake and harbor of sufficient force to maintain a 6-foot channel over the bar against the immense wave action, tending to completely close the channel.

At Chequamegon Point, near Ashland, Wis., the effect of these forces is very clearly illustrated by the changes that have occurred there during the past thirty-five years. This point, in 1852, was a narrow sand spit from 400 feet to 1,000 feet wide, and about seven miles long, extending partially across the mouth of Chequamegon Bay. It is so situated that the oscillations from the lake can only approach the shore obliquely from the northwest. From 1852 to 1869 a continual erosion took place along the entire length of the point. In 1869 the point near the shore end was only about 300 feet wide, and was covered with timber. Some time, about 1872, a breach occurred near the shore end of the point, and soon afterwards widened to nearly a half mile in width. Since the opening of the breach no erosion has taken place to the northwest, along narrow portion of point. A heavy current flows back and forth through the cut, alternating about once every hour—the flow towards the bay being the stronger, owing to the ebb flow from the bay escaping much more readily through the deep water channel at the end of the point. The action of the current through the breach has deadened the littoral current to the northwest of the cut. The point at the north side of cut is being gradually eroded, and as it recedes it is followed by the sand-point from the main shore. (See Plate 2.)

The cure for this trouble proposed by a recent Engineer Board is to permanently close the breach with a pile dike. This recommendation needs no comment.

The above are fair examples of the physical phenomena to be

found at most of the lake harbor entrances. That these oscillations exist, as has been stated, no one familiar with the lakes will deny. That their effect is different from that of tidal action is difficult to conceive.

XLII.

ON THE MANUFACTURE OF EYE BARS FOR PIN-CONNECTED STRUCTURES.

By William Sellers, Active Member of the Club.

Read April 21st, 1888.

I submit herewith some specimens of steel eye bars made by the Edge Moor Iron Company, that have been pulled to destruction to show the capacity of the heads to withstand a strain that will break the bar.

Wrought iron eye bars have long been used, their greatest importance in bridge building dating from the introduction of the wrought iron pin-connected truss in bridge structures. The production of these wrought iron bars has been modified from time to time to overcome the defects which their more extended use developed. At first, the eye was formed of a separate piece from the bar and then welded to it, next the end of the bar was piled with additional material, the mass welded together and shaped in a die, and next the end of the bar was upset to provide the material for the eye, the upset mass welded together and shaped in a die. All of these different modes of manufacture are in use at this day, and by all of them an eye can be produced that will be strong enough to break the bar. It may be asked, therefore, what advantage, aside from the cost of production, has one method over another.

In all of these different processes there is an element of workmanship which involves a personal liability to error. The skilled workman with great care can produce a perfect eye bar by the first process, but a failure of his heat or an imperfect condition of his welding surfaces may produce a defect, invisible to the eye,

but which yet may cause the bar to fail at a strain far below that which it is calculated to sustain; by the second process this liability from personal error is diminished, and in the third it is least of all, so that engineers with great unanimity discredit the first process and give a preference to the last over either of the other two.

To avail ourselves of the theoretical advantages of this last method, certain conditions must be observed which have involved years of labor and experiment to attain, although, at first, the problem seems to be simple enough. We have been accustomed to upset bars of iron from time immemorial, but heretofore such upsets have been small in proportion to the size of the bar. We are now called upon to make an upset very large as compared with the bar, and as the final operation is to shape the eye in a die of the proper form, that being an element in both of the earlier methods, it is necessary that the bar should be thickened as well as spread. In the earlier attempts to solve this problem, the bar was placed between two dies having a distance apart equal to the desired thickness of the upset, and in this position it was subjected to end pressure, so as to thicken and spread it at one operation, and many thousands of eye bars were thus formed, but this was before the days when such bars were pulled to destruction to determine their actual value. As soon as it became customary to subject such bars to destructive tests it was found that all such bars failed in the eye, because the bar, when softened by heat and subjected to end strain, would fold in the die; that is, it would first yield in the direction of least resistance and bend until this first bend was limited by the face of the dies, and as the upsetting proceeded a second bend would occur in the opposite direction, so that if the upsetting was arrested at this point, and the bar was taken from the dies, it would present a sinuous appearance, without being thickened or spread; if, however, the upsetting is continued, these sinuous folds are pressed together at the close of the operation, and the bar will also be thickened and spread ready for the final operation of flattening and spreading the eye to the required form in the finishing die, but when finished the two foldings, although invisible to the eye in the finished product, still exist, and at one or the other the eye will break before the bar is

strained near to its breaking point. To avoid this folding the next step was to divide the operation of thickening and spreading so as to thicken first and spread afterwards, and this was entirely successful so far as iron bars were concerned; to accomplish this thickening the bar was held upon its edges between two V-shaped dies, which would prevent it from bending in any direction or from spreading, but would permit it to thicken under the upsetting pressure; this thickened upset was then reheated and spread between dies at a second upsetting operation, and it was again reheated and flattened in another machine at the final operation, thus requiring one heating and two reheatings for each eye, but reducing to a minimum the personal liability to error in the workmanship. During a large portion of the time required to work out this solution of the problem, how to make iron eye bars, the value of steel for the same purpose was being slowly recognized; but when it was attempted to apply the system which had been successfully worked out for iron to the new metal very serious difficulties were at once encountered, and it was soon discovered that the method by which the personal liability to error had been eliminated in the manufacture of iron bars was the very one by which they were introduced in the manufacture of such bars in steel.

This was due entirely to the different conditions under which the two metals required to be worked; and as habit holds almost the first place in our mental as well as in our physical operations, the problem was complicated by the difficulty of educating men to new habits, that is, to treat the same metal in a very different manner in one physical condition from that they had been accustomed to do in another.

The final treatment in the manufacture of all iron eye bars is a flattening and spreading operation, which requires that the metal shall flow with facility. This treatment was given with great success at a welding heat within a die, from which the surplus metal would flow under the powerful pressure to which it was subjected; but with steel bars it is essential that the final work shall be given at a low red heat, and to effect the best results the amount of this work must be such as to produce, at the very least, a measurable disturbance of the whole mass treated. It was found

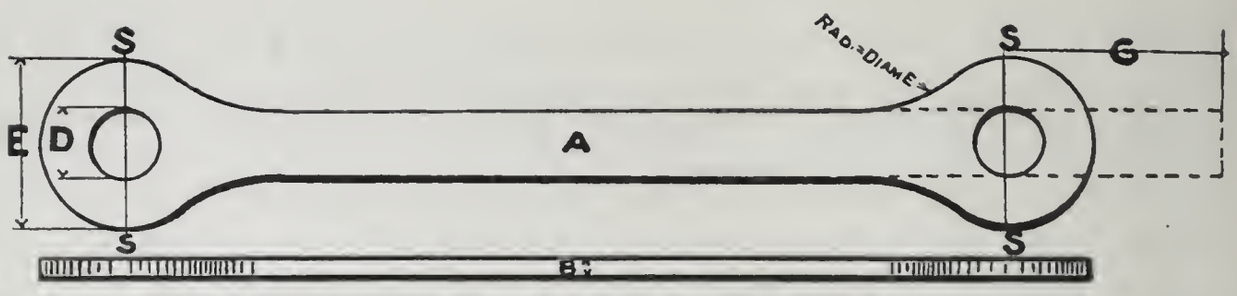
to be impossible, with this metal at the proper temperature, to effect the necessary reduction in thickness by subjecting the whole surface of the eye to pressure in a die; and pressures upon smaller areas within a die also failed, because the plunger which transmitted them could not be maintained, that is to say, its end surfaces were distorted and the plunger itself was upset, quite as easily as the metal in the eye could be made to flow at the low temperature desired when it was confined in a die. It became necessary, therefore, to reheat the upset portion, to flatten it in a die, and frequently several reheatings were necessary. These reheatings so near the end of the process must be under the control of workmen often ignorant of and generally unappreciative of the danger which may result from finishing at too high a heat, and defects from this cause afford no evidence which the engineer can detect without testing to destruction, so that the modifications of the latest process, which the new metal rendered necessary, introduced a personal liability of error, quite as great as any theretofore existing. To meet these new conditions the use of flattening dies for the final operation was incompatible, as they required the metal to be at a high temperature, whereas the steel required that the final operations should be performed at a low temperature. It became desirable, therefore, to spread the bar to the required dimensions and shape without increasing the thickness, more than would be due to the spring of the dies under the great pressure to which they would be subjected in the upsetting operation. This thinner upset required not only a greater length of the unsupported bar to be upset, but it also required a greater pressure upon the bar, and this developed a difficulty not encountered in the double upsetting practiced in the manufacture of iron bars. The long flat bar between flat dies which supported it laterally had no support from these dies edgeways, so that under this increased upsetting pressure it was liable to bend in this direction, which, of course, would prevent it from offering resistance sufficient to cause it to spread. The problem then was, to prevent this lateral bending between dies, which must also afford the necessary room for spreading; and this was solved, finally, by providing a small central groove in the face of one of the flat dies, in the line of the movement of the upsetting plunger, into which groove a portion

of the flat bar was forced by placing on top of the heated bar a plate with a projection upon it corresponding to the groove in the die, then closing the dies upon the bar and plate, thus forcing a portion of the bar into the groove in the die. The dies were then opened, the plate removed and the dies again closed, but this time upon the bar only, and the upset was made at the same heat. After the completion of this upset it will be found that the bar has a rib on one side of it, which is to be taken off in the final flattening operation.

We have seen that with steel at the low temperature desired for finishing, flattening dies are impracticable, and such dies had theretofore given the required shape to the eye. It was necessary, therefore, to give the shape in the upsetting operation; this is accomplished by cheek pieces having the desired shape for the eye next the bar, which cheek pieces are supported laterally between the dies so that they could not spread; the end of the upsetting plunger is also shaped to conform to the outer portion of the eye; the surplus metal, if any, flows out laterally between the ends of the cheek pieces and the end of the shaped upsetting plunger, and this surplus metal is trimmed off at the same time that the hole for the eye is punched. After the upsetting operation is complete the bar is passed to a punch, which trims off any surplus metal at the centre of the eye and punches the hole for the pin, leaving an ample allowance for subsequent boring. The bar is now ready for the final operation of flattening, that is, of bringing it to the required thickness and finish. This is accomplished by passing it between chilled iron rolls, and as these operate upon lines, the metal, even at the low heat desired, is not able to resist the powerful pressure which they produce upon such very limited areas, but is reduced to the required thickness by two passes, in which it acquires a finish and an exactitude of thickness not heretofore attainable. This mode of finishing has the effect of elongating the eye without spreading it, so that the upset must be made shorter to compensate for this subsequent elongation; also the thickening by upsetting must not be excessive, otherwise the elongation from rolling would be excessive, and it would thus be difficult to approximate the desired shape.

To eliminate personal errors due to workmanship it is necessary

to produce the eye at one heat, for if this is accomplished, even if the bar is too highly heated when it goes to the upsetter, it will be practically impossible to finish the eye at too high a heat unless the bar is very thick. To accomplish this finishing of the eye at one heat, the pumping capacity which produces the pressure upon the upsetting plunger must be great enough to effect the upsetting operation in such short time that the eye will retain enough heat for the final rolling operation. This has been so successfully attained that a bar must be uncommonly proportioned, or perhaps I should say, disproportioned, to require more than one heat, so that steel bars can now be produced with even greater certainty than was ever accomplished with iron bars. In the manufacture of all eye bars it is the end of the bar alone that is heated; the greater mass of the bar is cold even when the end is at a welding heat. This condition of the bar has no effect upon iron bars, but is of material consequence in steel, for the steel bar at this stage of manufacture, if pulled to destruction, will almost certainly break at the point where the heated end merges into the cold part of the bar, so that after the forging operation is completed the steel bar must be annealed, which is not required for the iron bar. The annealing operation consists in bringing the whole mass of the bar to a uniform bright red heat and then allowing it to cool off slowly and uniformly, to which end it must be covered while cooling, so that currents of air cannot strike it, as such currents might cause it to cool irregularly. It is found that when steel eye bars are manufactured as described, the surplus of metal in the eye over that in the bar, to make the eye stronger than the bar, is much less than has been heretofore required for iron, so that the eye for a steel bar may be materially less than for an iron bar, and the difference between the sizes of the dies may be greater; that is to say, a greater variety of size of pins may be used for each die. The various sizes of dies required have been tabulated, and I submit herewith some blue print copies of this table as a matter of interest to those members who are interested in bridge building. You will observe that the surplus metal for each size of eye, when the largest pin for that size is used, ranges from 25 to 33 per cent., while the practice for iron bars required at least 50 per cent. of surplus.



DIMENSIONS IN INCHES.

A	E	D		G	A	E	D		G
Width of Body of Bar.	Diameter of Head of Bar.	Diameter of Largest Pin Hole.	Sectional Area of the Head on the Line *S S* in excess of that of the Body of the Bar.	Additional Length of Bar beyond centre of Eye required to form One Head.	Width of Body of Bar.	Diameter of Head of Bar.	Diameter of Largest Pin Hole.	Sectional Area of the Head on the Line *S S* in excess of that of the Body of the Bar.	Additional Length of Bar beyond centre of Eye required to form One Head.
2	$4\frac{1}{2}$	2	25%	$7\frac{1}{2}$	5	11	$4\frac{1}{2}$	30%	$17\frac{1}{2}$
2	$5\frac{1}{2}$	3	25 "	$11\frac{3}{4}$	5	$12\frac{1}{2}$	6	30 "	$23\frac{1}{2}$
$2\frac{1}{2}$	$5\frac{1}{2}$	$2\frac{3}{8}$	25 "	$8\frac{3}{4}$	6	13	$5\frac{1}{8}$	30 "	$19\frac{1}{2}$
$2\frac{1}{2}$	$6\frac{1}{2}$	$3\frac{3}{8}$	25 "	$12\frac{3}{4}$	6	$14\frac{1}{2}$	$6\frac{5}{8}$	30 "	$25\frac{1}{2}$
3	$6\frac{1}{2}$	$2\frac{3}{4}$	25 "	10	7	$15\frac{1}{2}$	$6\frac{1}{8}$	33 "	24
3	8	$4\frac{1}{4}$	25 "	$15\frac{3}{4}$	7	17	$7\frac{5}{8}$	33 "	$29\frac{1}{2}$
4	9	4	25 "	$14\frac{1}{2}$	8	17	$6\frac{1}{4}$	33 "	25
4	$10\frac{1}{2}$	$5\frac{1}{2}$	25 "	$20\frac{1}{2}$	8	19	$8\frac{1}{4}$	33 "	$32\frac{1}{2}$

NOTES.

Edge Moor Standard Eye Bars are hydraulic forged, without the addition of extraneous metal, and without buckles or welds, and are guaranteed under the conditions given in the above table to develop value of the bar when tested to destruction.

The heads on Standard Eye Bars are finished of the same thickness, "B," as the body of the bar.

Eye Bars with heads varying from the Standard, either in thickness or diameter, will be supplied at an additional cost.

The increased thickness of the head over that of the body of the bar is limited to one-eighth of an inch.

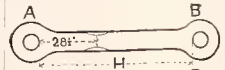
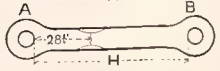
We contract only for finished Eye Bars, that is, with the eyes bored at the distances apart from centre to centre as required, and of right diameter to fit the size of the pin to be used.

The above relates to Steel Eye Bars.

Unless otherwise specified, Steel of the following quality will be used: Ultimate strength, 60,000 to 68,000 pounds per square inch; elastic limit, not less than one-half the tensile strength; elongation, from 17 to 20 per cent., the elongation to be measured after breaking on an original length of ten times the shortest dimensions of the test piece.

Reduction of area, 34 to 40 per cent.

REPORT OF TEST OF THE EYE BARS, SUBMITTED WITH PAPER BY WM. SELLERS

Date.	Mark.	A			Kind	B			Blow No.	Bar	Area.	Back to Back of Holes B	Elastic Limit.	Elongation of Hole		Per cent. of Elongation 8″	Per cent of Elongation 17′ 0″	Per cent of Elon. 100 ft	Per cent Reduction of Area.	Ultimate Strength.	Bill of Lading			
		Diam. of Eye.	Diam. of Pin Hole.	Per cent. of Excess.		Per cent of Excess.	Diam. of Pin Hole.	Diam. of Eye.						A	B						Test Number			
4.3.88	C	9″	$3\frac{7}{8}$″	31.6		33.7	$3\frac{7}{8}$″	9″	70,291	4″ × $\frac{29}{32}$″	3.64	18′ $0\frac{1}{16}$″	44,810	.36	.34	36.3	13.5	12.3	51.1	67,210	130			Ragged Silky
"	D	"	"	35.6		32.9	"	"	70,060	4″ × $1\frac{1}{8}$″	4.49	18′ $0\frac{1}{16}$″	43,750	.81	.42	42.0	16.0	15.4	55.0	64,390	131			Capped "

of the test piece.

Reduction of area, 34 to 40 per cent.

XLIII.

PUBLIC HEALTH OF CITIES AND TOWNS.

By Arthur Marichal, Active Member of the Club.

Read June 2d, 1888.

The improvements contributing to the welfare of cities and towns and to the accommodation of their inhabitants are undoubtedly the most useful ones which may be suggested. Unfortunately municipal authorities do not always realize this fact; they do not pay to such matters the attention it really deserves, and do their own way without reference to public sentiment. On the other hand, the public itself does not always contribute as it ought to in helping the authorities to carry out the necessary improvements, and in many instances the inhabitants cannot blame but themselves if their city is not in a better condition. I will confine my paper to the improvements relating to public health. They command necessarily the attention of every one; they contribute more than anything else to the welfare of a city. A healthy place is invariably a centre of attraction, and its population is growing rapidly. But it is evident that needs increase as the population increases; and that it is consequently necessary to watch carefully the growth of the population to be able to prepare adequate accommodation for the annual increment.

The probable percentage of increase of a population can always be determined with sufficient accuracy for at least ten years in advance. It is consequently easy to provide in time for the additional requirements. The water supply may be increased accordingly; additional sewers may be constructed; some more streets may be paved, etc.—this can all be done before the inhabitants are suffering from want of accommodation. But in most of the cases the growth of the population is not watched as it ought to be, and the necessary improvements are not thought of until after the people have been suffering for a long time from the results of this carelessness.

When a dozen theatres have been burned and thousands of persons have lost their lives, then municipal authorities begin to make laws regulating the construction and the management of

theatres! When hundreds of passenger trains have been thrown in the valleys on account of defective trestle work, then railroad companies begin to make inspection of their lines! When an epidemic has been ravaging a city, then the officials begin to talk about sanitary precautions! In other words, the remedy is always given when the patient is almost dead.

It may be said that such improvements, in accordance with the increase of population, are not always possible on account of lack of money. This could be the truth, but in most of the cases it is not, and the best proof is that such cities, claiming that they have no money for sanitary improvements, are throwing away millions of dollars in construction of luxury, intended to please the eye alone, although very often they do not please after all either the eye or the pocket-book of the taxpayer.

Water Supply.—An abundant supply of pure water is certainly a factor of the greatest importance in the sanitary condition of a city. The fact that water is no less essential to human life than air and food commands that its quality and quantity be at all times adequate to the requirements. The quantity of water to be distributed to a city could never be too large; it is limited only by financial considerations. A minimum admissible number of gallons per capita could hardly be determined; but it may be useful to give some idea about the average amount of water required for different purposes under normal conditions:

	Per capita per 24 hours.
For drinking and cooking, ...	1.50 gallon.
" cleaning clothes and habitations, . .	5.50 "
" toilet, ...	12.00 "
" water closet, sinks, etc., ...	8.00 "
	27.00 gallons,

making a total of 27 gallons required per capita per twenty-four hours, *if perfect cleanliness is to be secured.* As a matter of fact, many persons are using but half this amount, and many cities do not distribute more than 20 to 25 gallons per capita. It is almost unnecessary to say that the cleanliness of such cities must be very doubtful. It may be well to state that a horse drinks 10 gallons of water per day, and that it requires 50 gallons of water to keep horse and carriage.

Whatever care may be taken, water will never be perfectly pure; it will always contain some matter either in suspension or in solution, and although perfectly wholesome in appearance, it may be the cause of a slow poisoning of the people. Numerous statistics have been made proving that in cities having defective water works the death rate was relatively high, and as soon as the water was improved in quality, either by filtering or by a new source of supply, the death rate decreased considerably. As the population increases the sources of pollution of the water supply increase accordingly. Proper legislation should protect the rivers and reservoirs forming part of the system of water supply, in order to prevent sewage contamination. A water polluted by sewage is nothing else but a vehicle for carrying the germs of all diseases. But legislation alone is not sufficient; the sewage must be directed in some suitable way, hence the necessity of building adequate sewers. When these sewers are constructed, then the laws may be enforced and will prove efficient.

In many cities the water works are supplied neither with filters nor subsiding reservoirs, and after a heavy rain the water distributed to the people contains clay powder in more or less perceptible quantities.

It is often said that the presence of clay powder does not affect the quality of the water; but it is a mistake. Clay powder is decidedly injurious, and especially to children, causing inflammation of the bowels and other troubles, which remain generally unknown, although thousands of people are affected without knowing the exact cause of their sufferings.

Among the injurious mineral matters in solution in water, the salts of lime and the salts of magnesia, when in too large quantity, may be credited for many of the gastric diseases. Organic matter, either in suspension or in solution, may be the cause of various diseases, like malarial fever, typhoid fever, dysentery, and even cancerous and scrofulous diseases.

These examples will be sufficient to prove that water should never be used before having been purified. I do not intend to describe all the methods used heretofore in purifying water; I will only state that in my opinion the most effective process is the one in which the water is filtered through clay. This process is supe-

rior to all the others on account of the chemical properties of clay for the removal of the organic and inorganic matters, independently of the mechanical properties for the removal of matter in suspension. It has been proved that sewage filtered through clay became entirely inoffensive. While the filtering of water in small quantities is one of the simplest operation, the same is attended with great difficulties when it becomes necessary to filter large quantities like the whole supply of a city, and we should not be too hasty in blaming the administration of large cities if they have not yet erected a filter plant. But the erection of subsiding reservoirs is nothing but a question of money, and the neglect of building such reservoirs is unpardonable. Moreover, they should be built in time and not, as it is generally the case, after the people have been complaining for years of being supplied with muddy water. In many instances the inertia of the administration cannot be overcome by public sentiment, and this should not be a reason why people should poison themselves by drinking water not properly purified. If every property owner would consider a filter a no less essential part of a dwelling than a bath or a water closet, a supply of pure water would be enjoyed by the poor as well as by the rich, and that without appreciable cost to anyone.

Drainage.—The next thing to be considered in relation to the public health of cities and towns is the drainage. The removal of all filth as speedily as possible, and its disposal in such a way as not to be injurious to mankind, such is the problem to be solved in every city.

A system of drainage equally well adapted to every city would be very difficult to devise, local considerations making compulsory the adoption of different systems. But all of them should satisfy certain conditions, which I shall endeavor to point out.

The system of sewers should be such as not to allow any filthy matter to remain in it more than twelve hours. To obtain these results the sewers should have sufficient slopes and should be flushed every day. The flushing may be attended to by the police, consequently without any extra cost for labor, and that by simply opening the fire plugs. This method has the

treble advantage of cleansing the gutters and the inlets in the streets, and also of accelerating the flow in the sewers. Insufficient slopes and neglect of flushing have been the cause of the outbreak of cholera in many European cities.

I think it is useful to state that, no matter how perfect may be the flushing, some deposit will soon cover the bottoms of sewers, and that it will be a necessity to clean them regularly. Consequently the sewers should be large enough to allow a man to circulate in them; their minimum height should be three feet. It has been said that two separate systems of sewers should be constructed, one for the surface water and one for the filthy matter, that the sewers carrying the surface water could discharge nearer to the city. I cannot agree with these views. Surface water is always contaminated by organic matter from the streets, and after a couple of days putrefaction begins and deleterious gases are given off. Moreover, the double system is, in most of the cases, just as expensive after all. The single system, if properly constructed, will generally prove efficient, the rain and the flushing will accelerate the flow, thus contributing to the speedy removal of all filthy matter.

The ventilation of sewers is a question of the greatest importance, although, strange to say, very few cities have their sewers ventilated in some reasonable manner. The sewer gases, if not allowed to escape freely, become compressed by the rising water, and find their way either to the cellars of adjacent buildings or to the streets, through the manholes. The manholes should be made air-tight as much as possible. Ventilation pipes should be placed at the upper part of the sewer, should extend under the pavement to the house line, and from there carried above the roof of the buildings. These pipes should not be of large diameter, but should be numerous. It is almost needless to say that the part of the pipe attached to the front of the building could be made as ornamental as the property owner may desire.

Legislation should prohibit the maintenance of cesspools when there is a sewer in the street, as they are one of the greatest nuisances. It is well known to everyone that the germs of cholera are exclusively transmitted through the fecal matters. In a city where such matters are speedily removed the spreading of cholera is impossible.

Cholera is essentially an exotic disease. Although generated on another soil, the germs may be imported accidentally. As we do not know how to cure the disease, our duty consists in limiting its ravages, and this would be an impossibility in a city where cesspools are allowed. When the circumstances require the construction of a cesspool, it should be made perfectly water-tight, and the gases should not be allowed to escape, except through a pipe extending a few feet above the roof of the building.

In many cities the cesspools are not water-tight, and are located within a few feet from the dwellings. I have had occasion to convince myself of the fact that most of the cellars are converted in a reservoir of deleterious gases.

Not long ago, in one of the most populated parts of a city, some buildings were demolished and the ground excavated for new foundations. The excavated material was so strongly impregnated with fecal matter that it was impossible to approach the carts within ten feet; and this pestilence was vehicled in the middle of the day through the main streets of the city.

These examples will be sufficient to prove that the erection and maintenance of cesspools should be strictly prohibited, and that sewers should be built in every populated street of a city.

Inlets for the collection of surface water should not be more than four hundred feet apart when the streets are about level. They should be made of cast iron and provided with a trap. Inlets made out of bricks should never be constructed, on account of the porosity of brick work; in summer time they become a regular nuisance.

Paving.—The paving of a city is too often considered as merely a matter of luxury, while on the contrary it contributes highly to the sanitary condition of the place.

If the paving is defective the rain water cannot be carried promptly to the inlets. As I have already said, this water is always contaminated by organic matter from the streets, and, if allowed to remain until it evaporates, putrefaction begins and deleterious gases are given off. I have had occasion to see streets recently paved with Belgian blocks, where the blocks were placed across the whole width of the street, from curb to curb, in a perpen-

dicular direction to the curb stone; in other words, no gutters at all are provided, and most of the surface water does not disappear until complete evaporation.

Suitable gutters with sufficient slopes should be the very first thing to be thought of when paving a street. Belgian blocks placed lengthwise with a slope of at least 0.5 per cent. will make an effective gutter. A city should have a gang of paviors attending to the necessary repairs from the beginning to the end of the year.

Street Cleaning.—I think it is unnecessary to go into details about the necessity of cleaning the streets and removing all refuse with regularity. I will only call attention to the fact that these operations should be done during the night, for instance, between midnight and five o'clock in the morning, especially in populated districts. It is not a matter of convenience, but it is a matter of sanitary precaution. I do not believe that anyone would claim that it is safe to inhale all the dust accompanying the cleaning of the streets. It is just as easy to do it at night, and there is no reason why it should not be done. It may be said that the cleaning at night would cause some noise and disturb the inhabitants in their sleep. I will answer that this would be the case only during the first days; but after a short time they would become used to it, just as well as persons living near a railroad become used to the noise produced by the passing trains, and after a while they do not hear anything any more.

In almost every city of the world the cleaning of the streets is done in a most singular manner; it seems that this operation is intended to suit exclusively a certain class of people, instead of being accomplished with no other consideration than the question of public health. While the main streets are always cleaned with a certain regularity, the narrow streets and alleys, which are in the filthiest condition, are seldom, if ever, visited by a street cleaner. It seems that city officials think that their duty is to protect the rich and kill the poor.

Street Cars.—While I am talking about streets, it may be well to say a few words about the so-called rapid transit facilities of certain cities, and in doing so I do not intend to diverge from the subject of public health. There are, perhaps, few causes con-

tributing more to the increase of the death rate than the deliberate overcrowding of street cars. In some cities the people are packed in the cars not like human beings, but like cattle, and simply because the companies do not want to put more cars on their lines.

It is well known that phthisis and lung diseases generally may have their origin in breathing an atmosphere contaminated by respiration, even on the supposition that all the persons in the car are in ordinary health. But it may be suspected that in a crowd like we often see on the street cars, some one may be affected with some disease which although not contagious, literally speaking, may be transmitted by respiration of the vitiated atmosphere. Municipal authorities should limit the number of passengers to be admitted in each car, and the conductor as well as the police should see that the law be enforced.

I could not conclude without saying a few words about the defective construction of dwellings. Houses for the poor are generally packed in crowded streets, and built for the purpose of sheltering as many people as possible, and that at the sacrifice of ventilation, lighting, drainage, etc. It can hardly be said that there is any dwelling for the poor within the limits of a city. These so-called dwellings are generally located in narrow streets, they have small windows—if such they may be called—the rooms have often but 10 square yards of area, and the ceilings are sometimes but 6 to 7 feet high.

The time has certainly come for the municipal authorities to think about the poor, and to remember that although poor they remain human beings just as well as they are. Property owners would certainly pile one hundred dwellings, one on top of the other, to make more money without buying more ground. Proper legislation should prevent such disgrace to humanity. The minimum height of stories should be limited by law, as well as the minimun size of windows and doors. The total height of a house should be also limited, taking into consideration the width of the street. These laws should not only exist—they should also be enforced.

I would suggest that the height of a building should never exceed the width of the street, and that each story should be at

least 9 feet high in the clear. In any room where persons have to spend several hours, like a sleeping room or an office, at least 1000 cubic feet of space per capita should be provided. Each room should have 20 square feet of light per 1000 cubic feet of space, and no door should be less than 6.5 feet high and 3 feet wide.

I would like to go into many more details on this subject of public health, but I think I would trespass the limits of a paper of this character. I do not expect that my voice will awake the authorities of any city, but I hope that some other engineers will follow my example and raise their voices against these incredible neglects of the most elementary principles of Hygiene.

There was some discussion by Messrs. J. W. Redway, Edward Hurst Brown and Howard Murphy. Mr. Redway approved the idea of opening the fire plugs daily, as it would also remove the silt collecting in the water pipes.

XLIV.

GREAT TRANSPORTATION AREAS OF THE UNITED STATES.

By Prof. L. M. Haupt, Active Member of the Club.

Read June 2d, 1888.

All general questions relating to transportation must of necessity involve, amongst other things, the elements relating to the distribution of population, the location of the lines of least resistance, the character of the traffic, the distance to the market or *market-range* and the total cost of movement.

The latter item may be taken as the measure of most of the others. It is composed of a large number of variables, which for practical purposes have been reduced to a rate per unit of distance and of weight, whether by water or by rail.

A comparison of these units becomes therefore of great importance, as a basis for determining the limits of territory tributary to any particular route. Such a comparison was recently prepared,* showing the

* For a lecture delivered before the Manufacturers' Club of Philadelphia, entitled "The Commercial Paradox."—April, 1888.

RELATIVE RATES ON GRAIN IN BULK FROM CHICAGO TO LIVERPOOL.

RATE PER TON PER MILE IN MILLS.	RELATIVE RATES.	RELATIVE DISTANCES.	RELATIVE TRIBUTARY AREAS.	RELATIVE BENEFITS.
By Railroad 5.08	6.6	3	9	1
" Canal 3.04	4.	5	25	2.8
" Lake or River . 1.57	2.	10	100	11.1
" Lake *and* Canal . 2.00	2.6			
" Ocean 0.77	1.	20	400	44.4

From this table it would appear that, other things being equal, at canal rates the area benefited would be 2.8 times that at rail rates; at lake or river rates it would be 11 times, and at ocean rates 44 times greater, thus showing the superiority of movement in bulk with a minimum of fixed expense and low percentage of terminal charges.

It also exhibits clearly the fact that the cost of movement by water, whether in contracted natural or artificial channels, or upon the broad ocean, is much less than that by rail. Thus the overland rate is 1.6 times that by canal, 3.3 times that by river or lake and 6.6 that by ocean. There can be no doubt, therefore, that where it does not involve too many handlings or delays, it is desirable to ship when practicable by the ocean route.

Under the above conditions, the waterway must be regarded as the natural channel and the railroad as the feeder; but since the first must be used in its natural bed, the second has the great advantage of shortness and speed, combined with the ability to overcome greater physical obstructions. The main function of the railway is then to connect centres of population with one another and with the waterways. These two means form but parts of a harmonious system which are interdependent.

As in railways, the measure of the capacity of a line is that of its point of greatest resistance, so in waterways the same principle obtains, and the traffic of a through line is regulated by that where the least draft is to be found. Thus for ocean travel the tonnage and draft of the vessel is generally regulated by the depth of water over the outer bar at harbor entrances, where the greatest obstructions are to be found; in river navigation, traffic

may be entirely obstructed by a serious shoal, the removal of which may open up many miles of water transportation; and in canals the through traffic will be determined by the water available for the summit level. For many years the upper lake tonnage was restricted by the St. Clair Flats and the size of the lock chamber at the Sault Ste. Marie Canal. So the Five-Mile Bar in the Delaware is the practical limit of deep water navigation. Were it removed, 24 miles more of the river, having nearly 18 feet at low water, could be made available.

To determine the lines of least resistance, or of least cost, for the United States, it will be necessary to consider its topographical features and form, with reference to the most direct lines to tide water, the relative cost of movement by rail and water, and the distribution of population.

The United States may be said to be surrounded by water with the exception of that portion of the northern boundary extending from the Lake of the Woods to Vancouver's Island, a distance of about 1,300 miles, and of the southern boundary from El Paso Del Norte on the Rio Grande to the Pacific Ocean, a distance of about 670 miles. The Pacific coast line embraces in round numbers 1,500 miles; the Rio Grande, which is not navigable because of the bar at its mouth and its numerous shoals, 850; the Gulf coast, 1,500 miles; the Atlantic, 2,000, and the Lakes and Erie Canal 1,500, so that out of a total of 9,300 miles about 6,500, or 70 per centum, are navigable.

It is not proposed at this time to compare the relative advantages of the Atlantic and Pacific harbors, but to call attention more particularly to the facilities afforded by the northern and southern water frontages, so to speak.

The northern or Lake system extends from New York, via the Hudson River and Erie Canal, to Buffalo 502 miles, and thence about 1,000 miles to the heads of Lakes Michigan and Superior, where are to be found the natural centres of distribution and trans-shipment. The tributary areas of these two points will be found by drawing a perpendicular to the chord joining them at its middle point. This dividing line, extending in a southwesterly direction, will be found to pass through Iowa, Nebraska, Kansas, the northwest corner of the "Pan Handle" of Texas and

New Mexico; and hence it appears that for the great grain, mining and cattle industries of the Northwest the head of Lake Superior has the advantage over that of Lake Michigan by 400 miles, or less according to the latitude. The present depth of the Erie Canal is but seven feet. Hence, for foreign or coastwise traffic there must be three trans-shipments, viz.: at the port of clearance, at Buffalo and at New York or Montreal. The ruling depth on the Upper St. Lawrence is nine feet. This northern or lake route is also closed for about five months of the year, yet the tonnage through the Sault Canal to Lake Superior alone, during the season of navigation, is now at least equal to that through the Suez Canal during the entire year. By this water route the territory of the Lake Basin is enabled to secure the benefit of competitive rates.

On the southern boundary there is the Gulf of Mexico stretching for 1,500 miles from Key West to the Rio Grande, into which empties a system of rivers extending over thousands of miles of the great central basin, and reaching to within 30 miles of the northern system at Chicago. Recently the barrier separating the rivers from the Gulf was removed by the completion of the South Pass jetties, giving 30 feet of water instead of eight. The Gulf and the southern rivers do not freeze in winter so as to prevent navigation, and the only serious difficulty arises from the bars at the outlets of the rivers and bays emptying into the Gulf. With the exception of Pensacola and the South Pass there are no entrances in this long stretch of coast line having over $12\frac{3}{4}$ feet of water over the bar, and hence they are cut off from all other ports from which deeper draft vessels depart. In consequence, the commercial interests of this coast and the country tributary thereto have been but little developed, notwithstanding its greater advantages.

The east and west movement of the higher latitudes has no counterpart on the Gulf, yet it is often urged that the natural outlet for cereals and articles in bulk is down the Mississippi to the Gulf, and thence to the markets of the world.

Several reasons may be assigned for this; the first has been suggested already, namely, lack of sufficient depth of water; the second is the time required to make the trip. For whilst the dis-

tance from the mouth of the Ohio to the Pass along the axis of the river is about 630 miles, the distance by the channel is 1,130, or 80 per cent. greater, so that if the barges were to make the same velocity as the freight trains, it would require nearly double the time to reach tide water, and even then there would be but little, if any, gain in the direction of the ultimate market, which may be north or east.

It is also stated that in passing through the warmer latitudes the cereals germinate and become worthless. Whilst these objections may apply to some of the products of the upper country, they cannot be made to include those of the Southern States, as cotton, sugar, tobacco, cattle, etc. For the northwestern section and for the central belt of country lying west of the Mississippi, it would appear to be of great importance to construct the connecting water link between the great lakes and the Mississippi basin, and for the central and southern sections to complete the opening up of one or more deep water harbors for that section of the country not tributary to the Mississippi.

To determine the limit and extent of this territory, we may take the relative rates already cited, and, having the developed distance, may find the locus of the points of equal cost by rail direct to the river and thence to the Gulf; or, by rail direct to the Gulf. Thus let A be such a point x, its distance from the river, $= (A\ O)$ and d its distance from the Gulf $(A\ H)$. The rail rate is 3.3 times that by river and the distance $(O\,P)$ by the latter channel is 80 per cent. greater in consequence of the meanders, hence $O\,P = 1.8d$. The equation of rates will then be $1.8d + 3.3x = 3.3d$, or $x = \frac{1}{2}d$, which is the equation of a right line, the tangent of whose angle is $\frac{1}{2}$. The angle is therefore 26° 34′.

Taking the 91° of longitude as the meridian of the Mississippi Valley, and drawing these two radii from its intersection with the Gulf, it will give the sector of country which is theoretically tributary to the Mississippi. Practically this sector is modified

and limited by intersecting water courses in other directions, which would change somewhat the form of its boundaries.

The northern limit will be reached at or near the 40th parallel of latitude, from which, rates only being considered, it will cost the same via the lakes or the river to tide water. This transportation "divide" separates the territory into the grand divisions of lake, river and railroad.

At the existing relative rates the areas of these several divisions are:—

For the Mississippi River basin	about	300,000	square miles.
That tributary to the Great Lakes	"	500,000	"
The Atlantic Coast, escarpment	"	550,000	"
The Great South-Western, Gulf slope,	"	1,000,000	"
The Pacific area	"	700,000	"

In all of these the railroads play an important part and carry the volume of the traffic. Their general directions should therefore converge towards the principal ports. This would bring the trunk lines of the Texas district south, south-east and east, with connecting laterals. The more the commercial facilities by ocean are developed the greater will be the volume of business brought to the railroads. Thus an average ocean "tramp" of 2,000 tons net would supply loading both ways for about one hundred cars, but if there is no landing for the vessel it cannot bring the traffic. It is an old maxim in transportation that *facilities beget traffic.*

The area tributary to the Gulf is larger than any other, and is the least developed because of its comparative isolation. It embraces the larger part of that portion of the federal domain lying west of the river territory, which is also dependent upon railroads for the transportation of its products to tide water. To determine these subdivisions into northern and southern areas, let a line be drawn from Superior to Galveston, and bisect this chord at its middle point. This gives a line near the 39th parallel, which is also that of the centre of population. But as the northern water route is closed five-twelfths of the time, requires two trans-shipments in excess of the southern route, and is a cross country instead of a down grade line, the practical position of the divide would be shifted much

farther north, and may, I think, reasonably be placed about the northern boundary of Colorado. Thus it will be seen that, although the air line distance from Denver to Superior is less than to the Gulf, there are other physical as well as commercial considerations which would make the latter route the better one.

The location of Denver as a transportation centre is strategic, for if a circle be described about it with a radius extending to Chicago, it will include a large part of the Mississippi River, touch the Gulf coast between Galveston and Aransas Pass, the Pacific Ocean from Point Conception to Lower California and pass through the Bay of San Francisco. The most accessible water frontage is found on the Gulf, which is therefore the nearest eastern shipping port for the vast territory included in Texas, New Mexico, Arizona, Nevada, Utah, Colorado and parts of Nebraska, Kansas, the Indian Territory and Mexico, and embracing nearly or quite 1,000,000 square miles or 640 million acres. It is a magnificent empire awaiting the completion of the government works to secure deep water at some one or more passes on the Texas coast.

This being accomplished, there will be a rapid development of railroad construction in this section, radiating from the Gulf to the Northwest, and a great impetus to manufactures, agriculture, irrigation works and the numerous industries accompanying the providing of facilities for cheap transit.

Texas is the door, but time has locked and barricaded it with sand, which, thus far, the efforts of man have been unable to open and remove. This is one of the most important problems of the future. So important has it become that the people of this section of the country have called a general convention to meet at Fort Worth, Texas, on the 10th of July next, to discuss and consider the question of creating a deep water harbor at some point on the Gulf coast, west of the South Pass. It is a subject of great interest to all departments of engineering, and hence I have taken the liberty of inviting your attention to it.

NOTES AND COMMUNICATIONS.

THE ANDERSON PROCESS OF WATER PURIFICATION ON A LARGE SCALE.

Regular Meeting, January 22d, 1887.—Mr. E. S. Hutchinson presented a description of the apparatus, as given by the inventor and as in use in several European cities. The water, after settling, is forced through a revolving purifier, which consists essentially of a wrought-iron cylinder, mounted on hollow trunnions, serving for inlet and outlet pipes. The curved ledges, running lengthwise of the cylinder on the inner surface, scoop up and shower down through the current of water fine borings of cast iron. By the combined motions of the cylinder and of the water current, every portion of the water is brought into contact with the iron, the particles of which are kept constantly bright by friction against the sides of the cylinder, against each other and the water.

He illustrated by a black-board sketch the general outline of the purifier and its connections, giving rate of revolution, velocity of flow of water, amount of iron required, cost of purification and of plant, and other results of some years successful experience with the process.

The table of analyses which he gave showed that exceptionally bad and even dangerous drinking waters were rendered not only innocuous but wholesome by this method, the organic impurities being for the major part removed, the hardness reduced 40 to 50 per cent., and a brilliant appearance imparted to them.

THE INCREASED WEIGHT OF LOCOMOTIVE ENGINES, AS AFFECTING THE STRAINS ON RAILWAY BRIDGES.

Regular Meeting, February 5th, 1887.—Prof. L. M. Haupt called attention to this subject and instanced the following dimensions of an engine recently constructed at the Baldwin Locomotive Works.

Service,	Freight.
Gauge,	4 ft. 8½ ins.
Number of driving wheels,	10
Diameter " "	45 ins.
Truck wheels, number,	2
Driving wheel-base,	17 ft.
Total wheel-base of locomotive,	24 ft. 4 ins.
Wheel-base of tender,	14 ft. 5 ins.
Total wheel-base of locomotive and tender,	49 ft. 2 ins.
Extreme length of locomotive and tender,	63 ft. 3½ ins.
Boiler, diameter,	68 ins.
Tubes, 270 in number, 2½ ins. diam., 13 ft. 6 ins. long,	
Firebox, 121 $\frac{3}{16}$ ins. long, 42⅝ ins. wide, depth 60½ ins. f,	57 ins. b.
Heating surface of tubes,	2,148 sq. ft.
" " firebox,	162 sq. ft.
Total heating surface,	2,310 sq. ft.
Weight in working order, greatest on 1 pr. drivers,	27,000 lbs.
On all drivers,	134,000 lbs.
Total weight of engine,	148,000 lbs.
Weight of tender,	82,000 lbs.
Weight of locomotive and tender,	230,000 lbs.

Capacity of tender: coal, 16,000 lbs.; water, 3,600 U. S. gallons.
Live load, 3,940 lbs. pr. ft.

ENGINEERS' CLUB

OF

PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

LIST OF MEMBERS

March, 1888.

HOUSE,

No. 1122 GIRARD STREET,

PHILADELPHIA, PA.

PAST OFFICERS.

1878.

President, Prof. L. M. Haupt. *Vice-President*, Coleman Sellers, Jr.
Secretary and Treasurer, C. E. Billin.

1879.

President, Thos. C. Clarke. *Vice-President*, J. B. Knight.
Recording Secretary, Herman Hoopes.
Corresponding Secretary and Treasurer, C. E. Billin.
Directors: Rudolph Hering, W. G. Neilson, Percival Roberts, Jr., Coleman Sellers, Jr., and D. Mc. N. Stauffer.

1880.

President, Frederic Graff. *Vice-President*, Percival Roberts, Jr.
Recording Secretary, Wilfred Lewis. *Corresponding Secretary*, Howard Murphy.
Treasurer, A. R. Roberts.
Directors: Geo. Burnham, Jr., Rudolph Hering, Herman Hoopes, Coleman Sellers, Jr., and John A. Wilson.

1881.

President, Strickland Kneass. *Vice-President*, Henry G Morris.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.
Directors: Geo. Burnham, Jr., T. M. Cleemann, Jos. J. de Kinder, Frederic Graff and Rudolph Hering.

1882.

President, Rudolph Hering. *Vice-President*, Percival Roberts, Jr.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.
Directors: T. M. Cleemann, Jos. J. de Kinder, Frederic Graff, Strickland Kneass and Wilfred Lewis.

1883.

President, Henry G. Morris. *Vice-President*, Wm. A. Ingham.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.
Directors: Frederic Graff, Strickland Kneass, T. M. Cleemann, Rudolph Hering and Percival Roberts, Jr.

1884.

President, Col. William Ludlow. *Vice-President*, Jos. J. de Kinder.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.
Directors: Frederic Graff, Washington Jones, T. M. Cleemann, Rudolph Hering and H. G. Morris.

1885.

President, Joseph J. de Kinder. *Vice-President*, Jos. N. Du Barry.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.
Directors: T. M. Cleemann, Frederic Graff, Rudolph Hering, Col. William Ludlow and H. G Morris.

1886.

President, Washington Jones. *Vice-President*, T. M. Cleemann.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.
Directors: Frederic Graff, Rudolph Hering, Wm. A. Ingham, Col. Wm. Ludlow and H. G. Morris.

1887.

President, Thomas M. Cleemann. *Vice-President*, Joseph M. Wilson.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.
Directors: John T. Boyd, C. W. Buchholz, Frederic Graff, Washington Jones and M. R. Mucklé, Jr.

PRESENT OFFICERS.

1888.

President, Joseph M. Wilson. *Vice-President*, John T. Boyd.
Recording and Corresponding Secretary and Treasurer, Howard Murphy.
Directors: Thomas M. Cleemann, Frederic Graff, Prof. L. M. Haupt, Washington Jones and H. G. Morris.

List of Members

WITH

Address and Date of Election.

Members are particularly requested to keep the Secretary constantly informed as to their correct addresses.

HONORARY MEMBERS.

Haupt, Gen. Herman, April 6th, 1878.
Civil Engineer,
Mountain Lake, Giles Co., Va.

Robinson, Moncure, April 6th, 1878.
Civil Engineer,
1319 Spruce St., Phila.

ACTIVE MEMBERS.

Abercrombie, F. P., June 16th, 1883.
Assistant Engineer P. R. R.,
Sunbury, Pa.

Africa, J. Simpson, June 18th, 1881.
Civil Engineer, President Union Trust Co.,
613 Chestnut St., Phila.

Amweg, Fred. J., Nov. 5th, 1887.
Engineer in Charge Market St. Bridge, Phila.,
834 N. 40th St., Phila.

Arnold, Sydney W., Jan. 8th, 1887.
Civil Engineer,
1123 Spruce St., Phila.

Ashbridge, R. I. D., March 3d, 1888.
Asst. Engr. Manayunk Intercepting Sewer, Phila.,
4408 Sansom St., Phila.

Ashburner, Chas. A., Dec. 17th, 1877.
Geologist and Engineer Fuel-Gas and Elec. Eng. Co., Ltd.,
Penn Building, Pittsburgh, Pa.

Auchincloss, W. S., March 5th, 1881.
Civil Engineer,
209 Church St., Phila.

Bache, R. Meade, Nov. 1st, 1884.
Assistant U. S. C. & G. Survey,
4400 Sansom St., Phila.

Baermann, P. H., March 5th, 1881.
Civil Engineer,
P. O. Box 228, West Troy, N. Y.

Baizley, Rudolph R., June 20th, 1885.
Mechanical Engineer,
520 S. Delaware Ave., Phila.

Baldwin, Wm. Henry, Feb. 5th, 1881.
Civil Engineer,
34½ Pine St., N. Y.

Bamber, Herbert, Jan. 14th, 1888.
Civil Engineer, Supt. of Construction 4th L. H. District,
Light House Engineers' Office, Phila.

Barnard, Louis H., April 7th, 1883.
Prof. Civil Engineering State College,
State College, Centre Co., Pa.

Barnes, Edward H., March 15th, 1884.
Civil Engineer Duluth, South Shore & Atlantic R. R.,
Marquette, Mich.

Barnes, Oliver W., June 16th, 1883.
C. E., Chn. Com. on Construction, New Croton Aqueduct Comn.,
57 Broadway, N. Y.

† **Bartol, Barnabas H.,** Jan. 14th, 1888.
Mechanical Engineer,
1900 Spruce St., Phila.

Bassett, C. Phillips, Feb. 20th, 1886.
Civil and Sanitary Engineer,
Cor. Broad and Market Sts., Newark, N. J.

Beardsley, Arthur, Jan. 18th, 1879.
Professor of Civil and Mechanical Engineering,
Swarthmore College, Swarthmore, Delaware Co., Pa.

Bell, Geo. N., April 2d, 1887.
Civil and Sanitary Engineer,
427 Walnut St., Phila.

Bell, Samuel, Jr., Jan. 14th, 1888.
Assistant Engineer Penna. R. R.,
32d and Market Sts., W. Phila.

Best, James B., March 3d, 1888.
Best Steam Engine and Boiler Works,
333 E. Fulton St., Lancaster, Pa.

Biddle, Wm. F., Nov. 1st, 1884.
Civil and Mining Engineer,
209 S. 3d St., Phila.

Biernbaum, Max H., May 1st, 1886.
Civil Engineer Pencoyd Iron Works,
514 N. 5th St., Phila.

Billin, Chas. E., Dec. 17th, 1877.
Selling Agent for Rolling Mills and Forges,
Room 63, 115 Dearborn St., Chicago, Ill.

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† Deceased February 10th, 1888.

Birkinbine, Harry, May 1st, 1880.
Chief Engineer City Water Works Co.,
Council Bluffs, Iowa.

Birkinbine, John, Oct. 4th, 1884.
Civil and Mechanical Engineer,
25 N. E. City Hall Square, Phila.

Bixby, Wm. H., June 16th, 1883.
Capt. of Engineers U. S. A.,
U. S. Engineers' Office, Wilmington, N. C.

Bland, Geo. P., March 5th, 1881.
Civil Engineer,
3214 Woodland Ave., Phila.

Bonzano, Maximilian F., March 1st, 1879.
Supt. P. & R. R. R.,
9th and Green Sts., Phila.

Borda, Eugene, Oct. 2d, 1880.
Metallurgist and Mining Engineer,
326 Walnut St., Phila.

Borden, Philip D., Jr., Feb. 20th, 1886.
City Engineer,
Fall River, Mass.

Böttiger, Gustaf, March 3d, 1888.
Chief Draughtsman Clinch Valley Div. N. and W. R. R.,
Tazewell C. H., Tazewell Co., Va.

Bowen, F. H., Jr., Oct. 4th, 1884.
Assistant Engineer N. Y., L. E. & W. R. R.,
Leslie House, New Castle, Pa.

Boyd, John T. (*Vice-President*), May 1st, 1880.
Mechanical Engineer,
423 S. 15th St., Phila.

Bramwell, Geo. W., April 19th, 1884.
Civil and Mining Engineer,
No. 6 East 48th St., New York.

Brendlinger, P. F., Jan. 10th, 1880.
Chief Engineer R. & P. and P. & M. R. Rs.,
Pottsville, Pa.

Brewer, Paul C., April 19th, 1884.
Division Engineer C. & R. R. R.,
Reading, Hamilton Co., Ohio.

Briand de Morianville, V. E., March 15th, 1884.
Civil Engineer and Architect,
215 E. Chelten Ave., Germantown, Phila.

Bridgers, R. R., Jr., Nov. 7th, 1885.
Engr. M. W., Western N. Carolina Div., R. and D. R. R. Co.,
Asheville, N. C.

Brooke, Walter C., May 17th, 1884.
Civil and Mining Engineer,
Bramwell, Mercer Co., W. Va.

Broomell, A. P., Dec. 5th, 1885.
Broomell & Sanks, Steam Heating Engineers,
York, Pa.

Brosius, Milton L., Nov. 19th, 1881.
Mechanical Engineer,
Lewistown, Pa.

Brown, Edward Hurst, Jan. 8th, 1887.
Brown & Day, Architects,
1305 Arch St., Phila.

Bruner, Daniel P., Dec. 1st, 1883.
Civil Engineer,
Germantown, Phila.

Buchholz, Chas. W., May 1st, 1880.
Engineer of Bridges and Buildings; N. Y., L. E. & W. R. R.,
Room 55, 21 Courtlandt St., N. Y.

Burnham, Geo., Jr., Dec. 17th, 1877.
Civil Engineer Baldwin Locomotive Works,
500 N. Broad St., Phila.

Burnham, William, Dec. 17th, 1877.
Secretary and Treasurer Standard Steel Works,
220 S. 4th St., Phila.

Burr, Wm. H., May 2d, 1885.
Civil Engineer Phœnix Bridge Co.,
Phœnixville, Pa.

Cabot, W. Brooks, May 17th, 1884.
Civil Engineer,
West Medford, Mass.

Campbell, John W., Nov. 7th, 1885.
Assistant Supervisor P. R. R.,
1411 Eighth Avenue, Altoona, Pa.

Cassatt, A. J., Nov. 19th, 1881.
Civil Engineer,
233 S. 4th St., Phila.

Cassin, Isaac S., June 18th, 1881.
Mechanical and Civil Engineer,
1404 N. 12th St., Phila.

Chamberlain, Edwin, June 21st, 1884.
Civil Engineer,
1132 N. 6th St., Reading, Pa.

Chance, Geo. W., Jan. 14th, 1888.
Assistant Engineer Lake Erie & Western R. R.,
Indianapolis, Ind.

Chance, Dr. H. Martyn, Dec. 6th, 1879.
Geol. and Min. Engr., Ch. Engr. Brown, Howard & Co.,
Croton Aqueduct Tunnel Contrs., Hokendauqua, Pa.

Chaplin, W. S., Jan. 14th, 1882.
Prof. Engineering Harvard University,
16 Prescott St., Cambridge, Mass.

Chauvenet, S. H., Jan. 18th, 1879.
Manager Robesonia Iron Co., Limited,
Robesonia, Berks Co., Pa.

Chenoweth, G. D., Nov. 6th, 1886.
Assistant Supervisor P. R. R.,
Mount Holly, N. J.

Cheyney, Geo. S., Jr., June 20th, 1885.
Civil Engineer, Chief Engineer's Office F. E. & M. V. R. R.,
Missouri Valley, Iowa.

Christie, James, March 15th, 1884.
Mechanical Engineer Pencoyd Iron Works,
Pencoyd, Pa.

Church, J. B., July 1st, 1882.
Mining Engineer,
Geneva, N. Y.

Church, W. S., July 1st, 1882.
Assistant Engineer New Aqueduct,
215 Stewart Building, New York City.

Churchill, Chas. S., Nov. 7th, 1885.
Engineer M. of W., S. V. R. R.,
Milnes, Page Co., Va.

Claghorn, C. R., Oct. 4th, 1884.
Asst. Supt. and Min. Engr. S. L. & S. R. R. Co.,
Bernice, Sullivan Co., Pa.

Clarke, H. W., April 7th, 1883.
Engineer in Charge N. Y. & Pa. State Boundary Survey,
11 Granger Block, Syracuse, N. Y.

Clarke, Thos. C., Feb. 2d, 1878.
Union Bridge Co.,
Room 713, Wells' Building, 18 Broadway, New York City

Cleemann, Thos. M. (*Director*), April 20th, 1878.
Civil Engineer,
2135 Spruce St., Phila.

Clement, F. H., Jan. 14th, 1882.
Engineer and Contractor,
124 West 48th St., New York City.

Cloud, John W., June 21st, 1884.
Mechanical Engineer N. Y., L. E. & W. R. R.,
Buffalo, N. Y.

Codman, John E., Jan. 18th, 1879.
Assistant Engineer Phila. Bureau of Water,
3733 Spruce St., Phila.

Coe, W. W., May 6th, 1882.
Chief Engineer N. & W. R. R. and S. V. R. R.,
Roanoke, Roanoke Co., Va.

Coffey, Barton H., Jan. 14th, 1888.
Mechanical Engineer with Henry Warden,
18th and Allegheny Avenue, Phila.

Cofrode, Jos. H., March 5th, 1881.
Bridge Builder,
257 S. 4th St., Phila.

Colton, O. B., Dec. 17th, 1877.
Supt. and Purchasing Agent Fort Worth & Rio Grande Ry. Co.,
Fort Worth, Texas.

Constable, Howard, Feb. 16th, 1878.
Engineer and Architect,
149 Broadway, N. Y.

Constable, Stevenson, April 2d, 1881.
Civil and Mechanical Engineer,
707 Walnut St., Phila.

Converse, John H., May 17th, 1884.
Baldwin Locomotive Works,
500 N. Broad St., Phila.

Cooper, Frank, Nov. 5th, 1887.
Civil Engineer,
Mount Airy, Phila.

Cooper, Wm. A., March 2d, 1878.
Mechanical Engineer with Alan Wood Co.,
Conshohocken, Pa.

Corlies, Franklin H., Oct. 2d, 1880.
Mechanical Engineer with Wm. Sellers & Co.,
1612 Vine St., Phila.

Cornelius, H. R., Jan. 9th, 1886.
Mech. Engr. Southwark Foundry and Machine Co.,
430 Washington Ave., Phila.

Corthell, E. L., June 20th, 1885.
Civil Engineer,
205 La Salle St., Chicago, Ill.

Covode, J. H., Nov. 7th, 1885.
Assistant Supervisor P. R. R.,
Lancaster, Pa.

Cox, Allan, Nov. 7th, 1885.
Civil Engineer M. & B. S. R. R.,
Maysville, Ky.

Coxe, Eckley B., June 21st, 1884.
Mining Engineer,
Drifton, Luzerne Co., Pa.

Coxe, W. E. C., Nov. 1st, 1884.
President Montour Iron and Steel Co.,
Reading, Pa.

Craighill, Wm. P., Nov. 7th, 1885.
Colonel, Corps of Engineers, U. S. A.,
1734 St. Paul St., Baltimore, Md.

Cramp, Chas. H., Jan. 18th, 1879.
Ship Builder,
1736 Spring Garden St., Phila.

Cramp, Edwin S., March 5th, 1881.
Marine Engineer,
1515 Oxford St., Phila.

Cranmer, W. Clarence, Jan. 18th, 1879.
Surveyor and Regulator 3d Phila. Survey District,
719 Sansom St., Phila.

Crawley, Edwin S., March 3d, 1888.
Instructor in Mathematics University of Pa.,
34th and Locust Sts., Phila.

Creighton, Geo. W., Jan. 14th, 1888.
Asst. Engr. W. J. & C. & A. R. R's.,
Camden, N. J.

Cresson, Geo. V., Jan. 12th, 1884.
Machinist and Manufacturer,
S. E. Cor. 18th and Hamilton Sts., Phila.

Creswell, Samuel J., Jan. 24th, 1885.
Iron Founder,
23d and Cherry Sts., Phila.

Crizuka, Mataro, June 21st, 1884.
Mechanical Engineer,
Care of Frazar & Co., Yokohama, Japan.

Crowell, J. Foster, June 16th, 1883.
Engineer of Construction Cincinnati & Richmond R. R.,
Room 6, Little Miami Depot, Cincinnati, Ohio.

Cruse, Arthur R., Jan. 13th, 1883.
Mechanical Engineer,
39 Laurel St., Phila.

Culver, N. H., May 1st, 1886.
Architect,
901 Walnut St., Phila.

Cummings, Robert A., Jan. 14th, 1888.
Civil Engineer P. R. R.,
233 S. 4th St., Phila.

Darrach, Chas. G., April 20th, 1878.
Civil Engineer,
Ridley Park, Pa.

Datesman, George E., Nov. 7th, 1885.
Civil Engineer Dye & Datesman,
50 West Johnson St., Germantown, Phila.

Davis, James G., March 3d, 1888.
Assistant Engineer Phila. Bureau of Water,
757 S. 17th St., Phila.

Dawson, Edwin F., May 21st, 1881.
Civil Engineer,
2219 Green St., Phila.

Day, Conway H., April 2d, 1887.
Civil Engineer,
307 Cleveland Terrace, Camden, N. J.

Dechant, William H., June 21st, 1884.
Civil Engineer,
536 Penn St., Reading, Pa.

DeHaven, I. Norris, May 17th, 1884.
Foreman Wm. Sellers & Co.,
Box 61, Ardmore, Montgomery Co., Pa.

de Kinder, Joseph J., Dec. 6th, 1879.
Civil and Mechanical Engineer,
901 Walnut St., Phila.

Derbyshire, Wm. H., May 6th, 1882.
Mechanical Engineer with Bement, Miles & Co.,
21st and Callowhill Sts., Phila.

des Granges, John C., June 18th, 1887.
Division Engineer Chicago, Sante Fe & California Ry.,
494 Webster Avenue, Chicago, Ill.

Dice, Agnew T., Jan. 14th, 1888.
Assistant Engineer P. R. R.,
Harrisburg, Pa.

Dietz, Augustus, March 15th, 1884.
Mechanical Engineer Hoff & Fontaine,
1162 N. 3d St., Phila.

Dilks, Albert W., Dec. 1st, 1883.
Architect,
1001 Chestnut St., Phila.

d'Invilliers, Camille S., May 1st, 1880.
Assistant Engineer Penna. R. R. Co.,
Philipsburg, Centre Co., Pa.

d'Invilliers, Edward V., Jan. 10th, 1880.
Geologist and Mining Engineer,
711 Walnut St., Phila.

Dobson, Thomas H., May 1st, 1886.
Assistant Engineer W. Penn. Div. P. R. R.,
Blairsville, Pa.

Dodge, James M., Jan. 8th, 1887.
Mechanical Engineer,
123 N. 5th St., Phila.

Doyle, P., June 18th, 1887.
Civil Engineer, Editor "Indian Engineering,"
Spence's Hotel, Calcutta, India.

Du Barry, Jos. N., June 18th, 1881.
Third Vice-President Penna. R. R.,
233 S. 4th St., Phila.

Dunbar, Wm. O., March 7th, 1885.
Mechanical Engineer Test Dept. P. R. R.,
Altoona, Pa.

Dunne, H. W., Jan. 24th, 1885.
Superintendent New York, Phila. and Norfolk R. R.,
Cape Charles, Va.

Durham, C. W., June 16th, 1883.
President Durham House Drainage Co.,
158 W. 27th St., New York.

Dye, John H., March 6th, 1880.
Engineer and Surveyor,
100 West Tulpehocken St., Germantown, Phila.

Edwards, J. W., Oct. 4th, 1879.
Mining Engineer,
306 Santa Fe Avenue, Pueblo, Colorado.

Ehlers, Peter, March 5th, 1881.
Mechanical Engineer,
170 Broadway, Albany, N. Y.

Elmer, H. N., Dec. 1st, 1883.
Civil Engineer,
St. Paul, Minn.

Ely, Amasa, Nov. 6th, 1886.
Civil Engineer Phila. Bureau of Water,
13th and Spring Garden Sts., Phila.

Evans, Geo. M., Jan. 12th, 1884.
Engineer and Contractor,
Roanoke, Roanoke Co., Va.

Evans, L. P., May 21st, 1881.
Civil Engineer,
Pottstown, Pa.

Evans, Richard, Dec. 6th, 1884.
Assistant Engineer Bureau of Surveys,
1725 Park Ave., Phila.

Evans, S. S., Jan. 8th, 1887.
Instructor in Civil Engineering Univ. of Pa.,
2106 Park Ave., Phila.

Fairfax, Henry, March 5th, 1881.
Engineer and Contractor,
Roanoke, Roanoke Co., Va.

Falkenau, Arthur, Jan. 8th, 1887.
Mechanical Engineer and Machinist,
11th St. and Ridge Ave., Phila.

Feister, Henry P., June 16th, 1883.
Civil and Mechanical Engineer and Manufacturer,
Franklin Machine Works, 515 Minor St., Phila.

Feldmann, Max B., Dec. 6th, 1884.
Chief Engineer Morris Tasker & Co., Ltd.,
635 Franklin St., Phila.

Felton, Herbert C., June 20th, 1885.
Sec., Treas. and Supt. Kaighn's Pt. and Phila. Ferry Co.,
Camden, N. J.

Ferrell, Joseph L., Oct. 2d, 1880.
Manager Southwark Foundry and Machine Works,
430 Washington Ave., Phila.

Field, Burr K., March 15th, 1884.
Secretary and Treasurer Berlin Iron Bridge Co.,
East Berlin, Conn.

Field, Robert P., April 7th, 1883.
Mining Engineer,
148 S. 4th St., Phila.

Flickwir, D. W., May 6th, 1882.
Superintendent Shenandoah Valley R. R.,
Roanoke, Roanoke Co., Va.

Fontaine, John B., Jan. 24th, 1885.
Mechanical Engineer Eagle Iron Works,
1646 Franklin St.. Phila.

Ford, P. D., March 7th, 1885.
Supervisor Division C, N. Y. Division P. R. R.
Tacony, Phila.

Forder, Emil, Nov. 1st, 1884.
Civil Engineer,
Revere House, Denver, Col.

Forsythe, W. T., June 20th, 1885.
Civil Engineer,
Lebanon, Russell Co., Va.

Francis, Harry C., March 1st, 1879.
Manager Kensington Engine Works,
Beach and Vienna Sts., Phila.

Francis, W. H., June 18th, 1887.
Mech. Engr., Sec. Kensington Engine Works, Limited,
Beach and Vienna Sts., Phila.

Franklin, Benjamin, Jan. 8th, 1887.
Instructor in Civil Engineering Univ. of Pa.,
1710 N. 18th St., Phila.

Frost, Geo. H., June 16th, 1883.
Editor "Engineering News,"
13 Tribune Building, N. Y. City.

Fuller, Allen J., July 1st, 1882.
Assistant Engineer Phila. Bureau of Water,
3313 Spring Garden St., Phila.

Gardiner, John, June 18th, 1881.
Surveyor and Civil Engineer,
P. O. Box 255, Tucson, Arizona.

Garrett, Jesse, April 19th, 1884.
Water and Gas Works Appliances,
Care of R. D. Wood & Co., 400 Chestnut St., Phila.

Garrison, F. Lynwood, June 20th, 1885.
Mining and Metallurgical Engineer,
Radnor, Delaware Co., Pa.

Geer, Harvey M., June 18th, 1881.
Civil Engineer,
Ballston, N. Y.

Gest, Alex. P., March 1st, 1879.
Assistant Engineer N. Y. Div. P. R. R.,
Jersey City, N. J.

Gill, John L., Jr., May 2d, 1885.
Consulting Engineer,
503 Woodland Terrace, West Phila.

Graff, Frederic (*Director*), Jan. 18th, 1879.
Hydraulic Engineer,
1337 Arch St., Phila.

Graham, John, Jr., May 1st, 1880.
General Manager Camden Iron Works,
Camden, N. J.